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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1380

Washington, D. C. ▼ Issued May, 1926

A PATHOLOGICAL SURVEY OF THE PARA RUBBER TREE (HEVEA BRASILIENSIS) IN THE AMAZON VALLEY

By

JAMES R. WEIR, Pathologist of the Expedition of the United States Departments of Agriculture and Commerce to Investigate the Sources of Crude Rubber in the Amazon Valley and Pathologist in Charge of Pathological Collections
Bureau of Plant Industry

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PREFACE

During the period from August 3 to November 26, 1923, the writer, as pathologist of the expedition of the United States Departments of Agriculture and Commerce to investigate the sources of crude rubber in the Amazon Valley, studied the diseases of *Hevea brasiliensis* and related species. These investigations have resulted in a wide acquaintance with plant diseases in this interesting forest region, and an extensive collection of forest fungi [1] bearing on the pathology of Hevea has been made. Many of the fungi found are very imper-

[1] Recognizing the value of illustrations in work of this nature, many reproductions of photographs are used. Those from the field were photographed by M. K. Jessup. The detail photographs are the work of Robert L. Taylor, of the Bureau of Plant Industry. Plates XV to XVIII are by J. M. Shull, of the same bureau.

For many helpful suggestions and assistance in determining doubtful specimens of fungi the writer wishes to acknowledge his indebtedness to C. L. Shear, W. W. Diehl, Miss V. K. Charles, and Miss A. E. Jenkins, of the Office of Pathological Collections of the Bureau of Plant Industry, and also to C. C. Plitt, of Baltimore, Md., for determining some of the lichens. Thanks are also due to Miss Sara Young and Miss E. K. Cash for assistance in bibliographic work.

fectly known. The range of hosts of many of the wood-destroying species often varies widely from that of the same species in the eastern Tropics. A few apparently have an American distribution only. A few of pathogenic importance have been found to be new to science. The appearance of new and interesting phases in the life history of old and well-known species is not uncommon. Owing to the presence in the Amazon Valley of practically all the usual tropical crops which have received little or no care after planting, the region is of great interest to students of plant diseases. In fact, the field is new, and with the exception of a few collections made by early botanists, very little mycological and no constructive pathological work has been done.

Many of the problems with which the rubber grower is concerned are in intimate relation to the fungous agents of disease. In the South American region this is especially true. Before measures for the control of fungous diseases or for the practical consideration of the problems arising therefrom in plantation work in which forest fungi are concerned can be introduced, it is necessary to have fundamental knowledge of the life histories of the causal organisms. To supply a part of this information with the view of becoming more familiar with the diseases concerned in the growing of rubber in the American Tropics is the aim of this bulletin.

The system of classification followed in the main is that of the investigators best informed on the subject. In the Tropics very few common names of fungi have been proposed; consequently the Latin names of the species are strictly adhered to. In cases where the effects of the fungus or the conditions producing the disease are highly characteristic, a common name for the disease is also employed. The number of species of fungi recorded on Hevea in the Amazon Valley seems unusually large. It is small, however, in comparison with the number associated with some of the economic crops of the world. The work has been conducted on the basis of giving as complete a survey of the fungi and diseases of Hevea as time would permit. A list of all the fungi known to occur on Hevea in any part of the world is included. Fungi are widely distributed, and the species shown in this study may be found throughout the tropical belt.

In the Tropics, where plant pathology is in its beginning, it seems desirable to record all fungi on a given host, for the reason that under the conditions of clearing away the native forest, fungi which now seem unimportant may later cause disease on the introduced crop. This has been largely true in the case of Hevea. Aside from the more practical consideration given to each fungus, some details with regard to the chief characteristics of the different species and the classes, orders, families, and genera to which they belong are presented. It is hoped that this will give the bulletin a wider usefulness from a taxonomic standpoint and will also explain many of the terms necessarily used in a work of this kind.

GENERAL PATHOLOGICAL CONDITIONS AND SANITATION

Not until the past few years have the diseases of tropical crops in America received much attention. Now that it is realized that serious economic loss will result unless some effort is made to combat

the existing dangers from plant diseases, considerable advance in several regions is being made.

The studies in the Amazon Valley show in no small way the economic importance of the factor of disease in relation to the more permanent crops and the revenue therefrom. Compared with the work that has been done in relation to the protection of field and forest crops in many parts of tropical America, practical work on the fungous diseases of important crop plants in the Amazon Valley has been entirely neglected, largely because of the inactivity of the people and the popular belief that the native plant products are inexhaustible and may be exploited in any manner that one with the necessary capital sees fit. Consideration of future economy by conservative methods of tapping and general care of trees, with a view to the promotion of future yields on the same site, is not a part of the plan for collecting rubber by the present owners of estradas. The rubber operator literally slashes right and left, and when the trees no longer respond to the methods employed he moves to unworked areas. This treatment of the more accessible trees has resulted in enormous damage, so that a large percentage of the wild rubber growth near the streams is in a condition no longer suitable for tapping. It is unlikely that many of these trees can be brought back to a proper state of health under a well-regulated forest working plan. After the more inaccessible areas are worked, the growing of rubber in plantations must of necessity be undertaken. Since the conditions in the Amazon Valley are suitable for growing enough rubber to supply the world, provided proper measures are taken to protect the crop against diseases, this will necessarily be the next step.

DISEASES OF HEVEA

Hevea in the Amazon Valley is attacked by a number of fungous diseases. This expression refers not only to certain wood-destroying and parasitic fungi acting on the root and stem, but includes a number of leaf parasites. This means reduced vigor, rapid death, or slow starvation if the attack is continuous. In some sections mistletoe adds its suppressing effects, and its cankers and burls afford an entrance to the spores of wood-destroying and other fungi and insects.

The planter who may contemplate the growing of rubber in the Amazon Valley may expect to find it necessary to combat the natural enemies of the tree. This is not alarming. It is a condition that must be met, as has been the case in the Orient, and is incidental to the successful growing of any crop anywhere. It is merely a part of the overhead. There is no reason to believe that the diseases of Hevea encountered in the Amazon Valley can not be successfully combated if proper precautions before and after planting are taken.

HOST RELATIONSHIPS

As a matter of further introduction to the more detailed discussion of particular problems it is interesting to note that many of the more serious diseases of the timber trees did not extend their ravages to Hevea, but confined their work to sets of hosts in no wise related to Hevea. For example, one of the most serious wood-destroying

fungi of timber trees in the valley is *Fomes fastuosus*. It was never found on any host except those belonging to the Lauraceæ and Rubiaceæ. *Polystictus iodinus*, causing a serious disease of stems, was found only on species of Rubiaceæ. Serious leaf blights were confined to Moraceæ and Urticaceæ. Examples could be multiplied. It is not believed that these diseases and several others found on forest trees will attack Hevea. This condition should be of significance in establishing plantations in the jungle.

REGIONAL PECULIARITIES

Different forest and soil formations bring about reactions of various kinds in the general habitat, so that regional peculiarities as regards the presence of disease are often apparent. This was observed in the case of Hevea. On the flood lands of the lower Amazon the trees in some localities showed a high percentage of infection both in the forest and in small plantations, but in a region at another altitude, having different forest and soil conditions, they were entirely free from their principal fungous enemies. Why the species may be fairly free from fungous attack in one region and show severe infection in another is difficult to explain. Its possible adaptation to particular soil conditions or climatic influences may furnish a profitable basis for future experimental work. The health of forests is usually very intimately correlated with the topography of the region. The formation of a forest and the successive stages of its development are found to be very definitely influenced by the physiographic evolution of the region. With the advance of Hevea from the highlands to the recently formed lowlands, it is by no means impossible of conception that the species has reacted in a way to make it more susceptible to disease, entirely apart from any immediate influence of the soil and water relation.

Aside from this broader conception, it is by no means fanciful to consider the possibility of bringing about a certain degree of natural immunity in planted Hevea. This would be done by a careful manipulation of nursery sites and of seedlings, by the selection of seeds or cuttings from trees showing a high state of health and vigor and growing in localities free from disease, and by a careful selection of planting areas. It would be the function of the plantation manager, aided by the plant pathologist and soil expert, to seek out these areas.

INTERCROPS

It is safe to assume that forest trees of the same species, having the same physiological and morphological organization and growing on the same site, require to a very large extent the same kind of food from the soil. The significance of this in relation to disease in plantations must be recognized by the planter. Uniform crowns, similar branching and natural pruning which cause wounds at the same level, equal depth and extent of root systems, equal annual increment, constant temperature, and uniform moisture and light relations, with few unfavorable influences, produce conditions that tend to increase or maintain fungous activity unequaled in plantations of mixed species. The truth of the proposition that fungous diseases spread more rapidly and cause greater damage in stands

composed of numerous trees of the same species is abundantly shown by the ravages of *Dothidella ulei* in the Guianas and in the lower Amazon, whereas the same fungus does not succeed in reducing the stand of Hevea in the natural forest. This leads to a consideration of intercrops. The gardener should plant other vegetables between his rows of cabbages, because it is known that the food requirements of the one are different from the others; in fact, the two crops may mutually benefit each other in various ways. One of the chief objects to be gained, however, is the prevention of the spread of disease by growing on the same site various crops not all of which are attacked by the same disease. The principle is an old one, and its value in mitigating the effects of fungi has long been recognized in both field and forest.

The success or failure of intercrops for Hevea will then depend upon whether they are equally susceptible to a particular disease or whether they are liable to overtop the Hevea in any stage of its early development. In the Amazon Valley the associated crops found in or around the small Hevea plantations either by accident or design consist usually of such plants as are attacked by the same class of root and stem fungi. (Pl. I.) Since there has been no real attempt to establish plantations except in a small experimental way, the present account must be confined to calling attention to plants which would be undesirable for intercrops for the above reasons. Petch has called attention to the fact that cacao is undesirable as an associate crop for Hevea and enumerates several diseases common to both. These diseases, with one exception, are found on both Hevea and cacao in the Amazon Valley. They are *Fomes lignosus*, *Diplodia theobromae*, *Phytophthora faberi*, and *Ustulina zonata*. In addition there are the Rosellinia diseases and mistletoes.

Caju (a common fruit of the Amazon), lime, orange, avocado, mango, and papaya were hosts either of parasitic or wound fungi found also on Hevea. The fungi were in most cases those already enumerated. Others of possible economic importance common to these hosts are omitted until there is an opportunity to study them in detail. Jungle trees carried a number of fungi found also on Hevea, notably *Fomes lignosus*, *Polyporus zonalis*, *Ganoderma australis*, *G. amazonense*, *Poria vincta*, *Trametes floccosus*, *Nummularia anthracodes*, and *Ustulina zonata*.

Very few of the fungi enumerated are parasitic, but practically all are capable of continuous growth or indefinite hibernation in dead substrata and only await an opportunity to attack vulnerable parts of living hosts when favorable conditions arise.

DESTRUCTION OF JUNGLE DÉBRIS

Owing to the fact that many of the important economic fungi attacking Hevea are common to the jungle and pass over from decaying or living forest débris to Hevea, the matter of the removal of this infectious material is of first importance.

There is no reason to believe that the natural physical conditions for the clearing of land in the Amazon Valley are any more difficult than in any other tropical region. It is not within the province of this bulletin to consider the cost of such an operation. Suffice it to state that every effort should be made to clear the land

completely before planting. The reasons for this are obvious. This means the removal of large stumps as well as all slash on the area. Since there is not likely to be an opportunity to dispose of any merchantable timber at a profit, the last recourse is to free the area of all jungle material by broadcast burning. Secondary burnings may be necessary for the destruction of large trunks after seasoning. (Pl. II, A.) The loss in soil fertility through the destruction of humus must necessarily be a secondary matter. The food-producing capacity of the soil can be restored by the interplanting of such crops as would tend to do that work without future injury to Hevea.

SPECIAL DISEASES

ROOT DISEASES

WATERY ROOT-ROT

The watery root-rot fungus (*Polyporus lignosus* Klotzsch) has been widely known in the tropical world for many years. Specimens in the department herbarium show it to come from all the rubber-growing regions of the Eastern Hemisphere. It was very early encountered during the present investigation at Para and was found throughout the entire Amazon Valley, but chiefly in the lowlands. Specimens are also present from southern Brazil. Its occurrence in the West Indies and Central America should be more thoroughly investigated. The fungus was first reported by Ridley, in 1904, as causing a disease on Hevea at Singapore. Since that time the fungus has been widely reported by various investigators.

The discovery of the fungus in the Amazon Valley now makes it one of the commonest of the root diseases known to attack Hevea. The host range of the fungus is very great. Although only four rubber trees were found attacked in widely separated parts of the valley, the fungus was invariably present on either living or dead trees or stumps of jungle trees in the different regions visited. As has been shown by Petch, the host range of the fungus is also very great in the East. In addition to Hevea the fungus was recorded on the roots of living hosts of the jack (*Artocarpus integrifolia*), coffee (*Coffea arabica*), coco palm, *Ficus* sp., and cacao.

The fungus was collected on a great variety of jungle stumps. The following is a record of these collections:

On living stumps, on partly decayed roots, or roots of living trees of *Hevea brasiliensis* (Euphorbiaceæ).
On dead log of mango (*Mangifera indica;* Terebinthaceæ).
On dead wood of Cecropia (Moraceæ).
On dead stump of muiratinga (*Olmedia maxima;* Moraceæ).
On dead stump of breadfruit (*Artocarpus incisa;* Moraceæ).
On dead stump of assacu (*Hura crepetans;* Euphorbiaceæ).
On dead stump of *Trichantheria gigantea* (Ancanthaceæ).
On dead roots of *Inga* sp. (Leguminosæ).
On dead roots of cutitiraba grande (*Lucuma macrocarpa;* Sapotaceæ).
On dead roots of munguba (*Bombax munguba;* Bombacaceæ).
On dead roots of andiroba (*Carapa guyanensis;* Meliaceæ).
On dead stump of orange (Rutaceæ).
On dead bark of *Aydendron permalle* (Lauraceæ).
On dead stump of *Tecoma* sp. (Bignoniaceæ).
On dead log of pao mulatto (*Calycophyllum spruceana;* Rubiaceæ).

On dead roots of *Calophyllum* sp. (Guttiferæ).
On dead wood of jarana (*Chytroma* sp.; Lecythidaceæ).
On dead roots of samauma (*Ceiba pentandra;* Bombacaceæ).
On living stump of cacao (Sterculiaceæ).
On dead stub of Cocos (Palmaceæ).
On dead wood of *Calycophyllum* sp. (Rubiaceæ).
On dead log of *Triplaris* sp. (Polygonaceæ).
On living stump of *Ficus* sp. (Urticaceæ).
On living roots of jack (Urticaceæ).

The above-named hosts represent a wide range of families and genera. There was no evidence of a marked proclivity of the fungus to adapt itself to any particular host. In most cases the hosts were of species which may be said to have soft wood, but one collection was made on the roots of an old log of *Calycophyllum spruceana*, one of the hardest woods in the Amazon Valley.

In all four cases of the fungus on Hevea the lateral roots were attacked. In one case both the laterals and taproot were attacked, resulting in the recent overthrow of the tree by the wind. It would appear that the fungus is of economic importance in the rubber-producing regions of tropical America and will result in financial loss if protective measures are not introduced along with the establishment of plantations. This statement, however, should be substantiated by further investigations on the parasitism of the American plant.

The external symptoms of the attack on the three standing trees were the production of sporophores within root crotches. These appeared on one side of the trees only. The trees exhibited eccentric development on the uninfected side, causing concavities to the right and left. This is in accord with the effects of root fungi on timber trees in the Temperate Zone. The fluted condition of the base may indicate that the taproot has been destroyed, the increasing girth then being more pronounced over the main lateral roots. The same phenomena were observed in the case of other forest trees of the valley when attacked by root fungi or where the laterals were otherwise destroyed. The foliage on the three trees was abnormally thin and in all stages of development; but, being at a season when defoliation was common, the condition had no significance. The failure of many small twigs of the last few nodes to produce leaves in the upper crown apparently reflected the health status of the trees. The internal symptom of the fungus is the presence of a soft watery decay. The diseased wood in the last stages of decay may be squeezed in the hand into a shapeless mass. The bark of the infected roots may exhibit a darker brown color than normal and when removed may exhibit white, yellowish, or reddish strands of mycelium on the under surface or embedded in the decayed wood (Pl. III, A). In some cases there was a development of a mycelial network of strands on the exterior of roots, as has been reported for the fungus in the East (Pl. III, A). This soft, spongy, watery decay was found in the roots of a Hevea tree that had been injured by fire. The rot when rolled up for a time in a paper bag produced the reddish yellow strandlike mycelial growth which was probably indicative of the presence of *Polyporus lignosus*.

The fructifications of the fungus on dead stumps (Pl. II, B) or standing dead trees rarely were found more than a foot above the ground. Usually originating in the hollow root crotches the fruit-

ing bodies either formed a continuous resupinate portion within the cavity up to an elevation where it became necessary to become reflexed for the proper development and dispersal of spores or remained entirely resupinate and became pileate only on the sides of the surface roots some distance from the base of the tree (Pl. IV). On fallen trunks elevated above the ground the fungus was usually entirely resupinate on the under side. On large trunks, such as Ceiba, this resupinate condition may be very extensive and develop over an area of 10 or 20 feet. On trunks lying directly on the ground the fungus for obvious reasons always produced the typical brackets. Occasionally the fungus would be found apparently growing from the ground, but it was always found attached by means of a false stem to a dead root or a buried piece of wood. In such cases the substratum was partially enveloped by white mycelial sheets or strands which extended away from the wood into the forest duff. Between the bark and the wood in such cases the mycelial layers were conspicuously developed. Beneath the bark the mycelial development took the form of a fine thin sheet of a silky sheen, without the development of cords (Pl. III, A). On the surface of the roots the sheets are interlaced with smooth white strands or cords forming a network or radiating at the margin of the sheets in fanlike extensions.

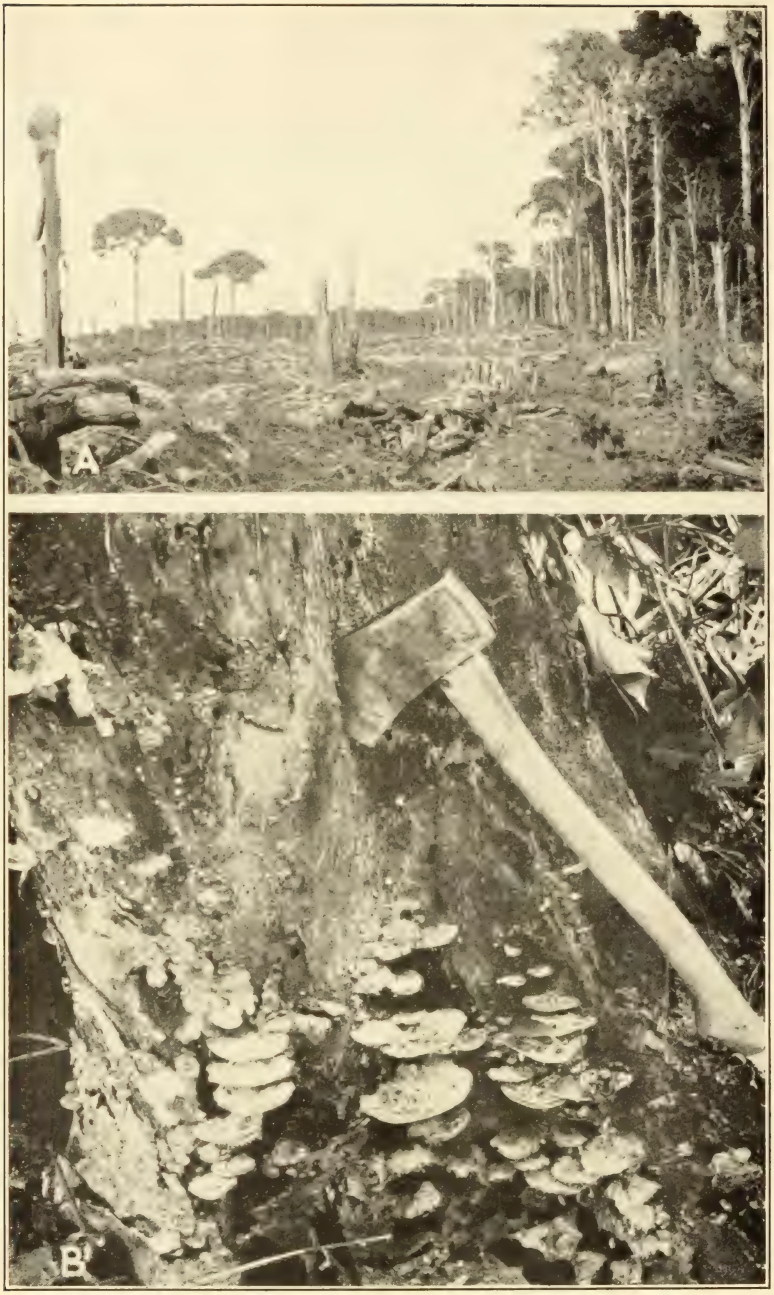
These cords are at first white and soft, but with age they become tough, yellowish, and discolored. This mycelial development is characteristic and may serve to detect the presence of the fungus. As is the case in some of the root fungi of the Temperate Zone there is every evidence that the fungus may travel by means of these mycelial threads from a seat of infection to uninfected roots of neighboring trees. This has been demonstrated in the East. For this reason the fungus is difficult to eradicate from plantation sites unless all jungle stumps are removed.

The depth to which the roots of trees are infected by this fungus depends upon the character of the soil and the kind of root system. In the hard fine-silted baked soil of the river flats the roots of a Cecropia stump were sound at a depth of 10 inches. The decay on the laterals (which extend into the earth at an angle of about 40°) and the taproots apparently ended abruptly at that depth. On high ground where the soil was porous and better drained the roots of the same species which had been exposed by a bank slide a few days before had been penetrated to a depth of 40 to 50 inches. The roots showed the characteristic white mycelium, with sporophore production at the root collar.

There are two main types of root systems of tropical trees, those with a well-developed taproot having laterals penetrating the earth at a sharp angle and those without a taproot but with laterals sprawling over or near the surface of the ground. The lateral roots in the last-named group are frequently conspicuously buttressed, a necessary provision in the absence of a taproot to give strength to the root system. The rubber tree belongs to the former group and may be infected and in a serious stage of decay without any evidence of the presence of the causal organism until after the tree is dead or overthrown by the wind.

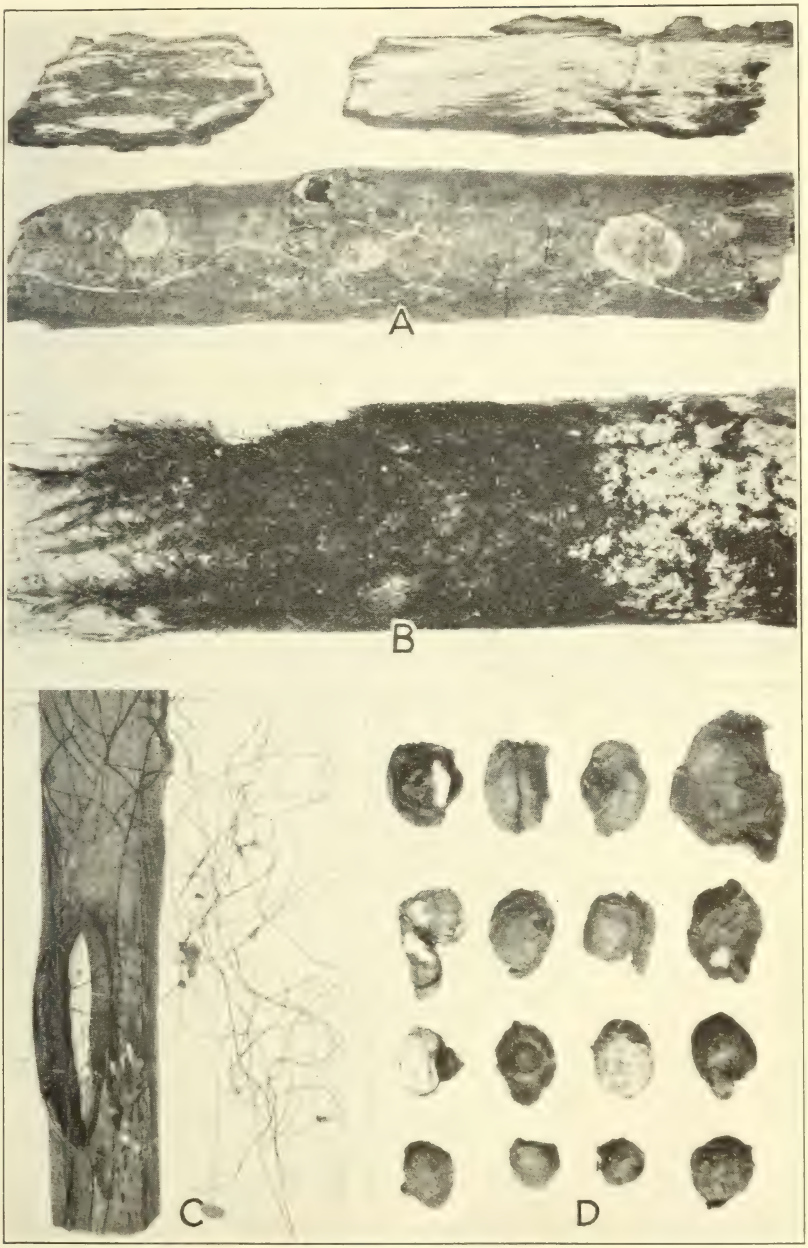
On the roots of the second group the fungus has an opportunity to extend its activities over a wide area, in which it comes in contact

CACAO INTERPLANTED WITH HEVEA AT URUCURITUBA, BRAZIL



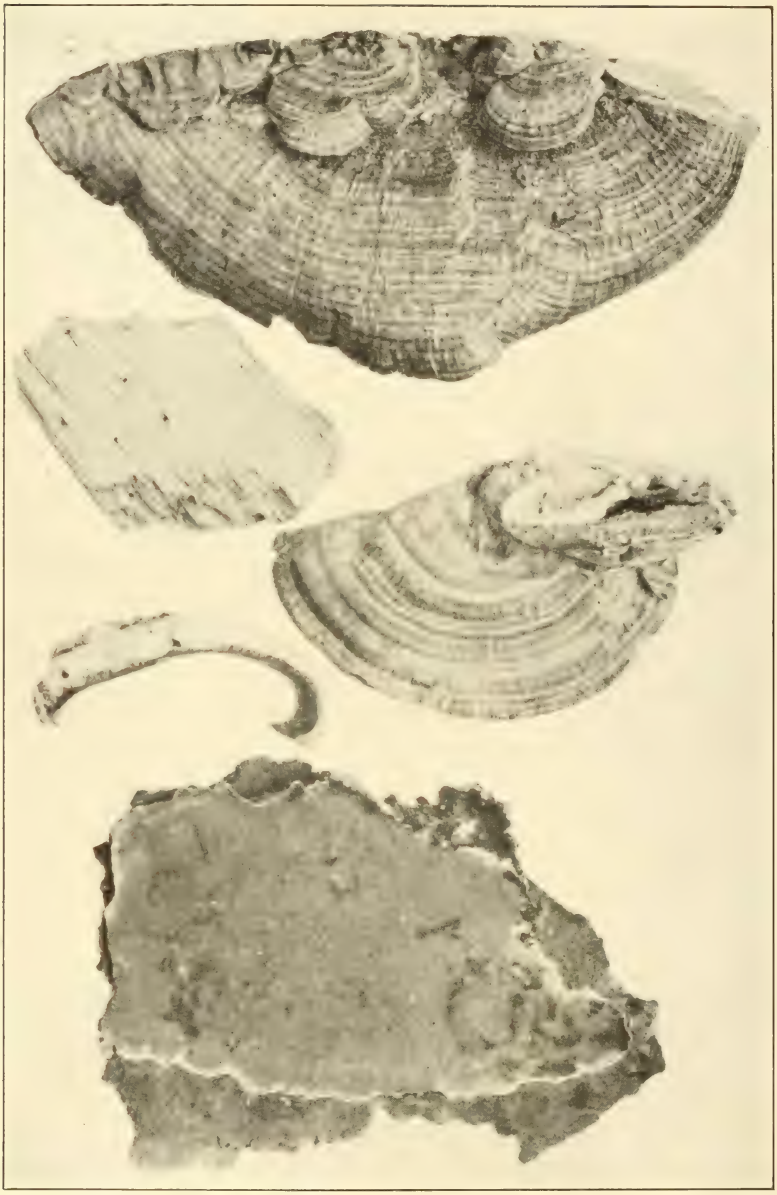
A CLEARING AND A FUNGUS COMMONLY DEVELOPING IN IT

A, Typical jungle clearing at Democracia, Rio Madeira; B, fructifications of *Polyporus lignosus* on a Hevea stump



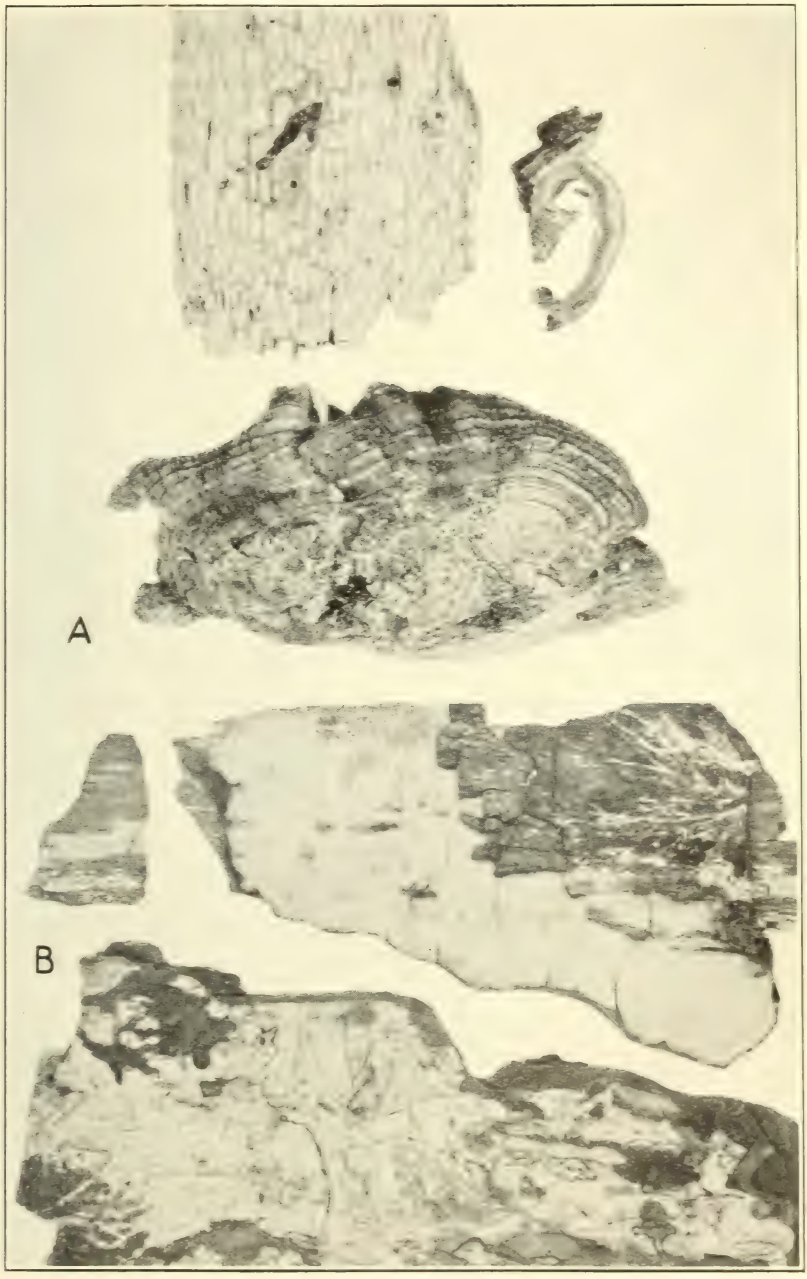
DISEASES OF HEVEA

A, Young mycelium of *Polyporus lignosus* beneath and on the outer surface of roots; B, Septobasidium on stem; C, horsehairlike strands of Marasmius; D, small spherical cortex nodules in and on the bark. (Nearly natural size)



POLYPORUS LIGNOSUS ON HEVEA

Reflexed and resupinate fructifications, showing undifferentiated condition of the decay. (Reduced about one-third)



ROOT DISEASES OF HEVEA

A, Fructification and differentiated decay of *Polyporus zonalis*; B, fructification, spreading mycelium, and rhizomorphs of *Poria vincta*

FRUCTIFICATIONS OF GANODERMA AMAZONENSE

(Reduced about one-third)

with the roots of the rubber tree and causes infection. A rubber tree in one instance was enmeshed with the roots of three other trees, all different species. These facts bear upon the problem of the nature and cause of the spread of this fungus on roots and the consideration of the elimination as far as possible of all stumps and trees on plantation sites. The forester is confronted with the same problem in the case of parasitic root fungi, but except in the case of small planted holdings control measures are not practicable.

The fruiting bodies of the fungus are among the most conspicuous of all tropical species. (Pl. IV.) Originating as a small knoblike protuberence, the fungus develops horizontally into a bracket or a semicircular shape. It is from a fourth to half an inch in thickness at the point of attachment and thins out regularly toward the margin. In exceptional cases the brackets may attain a length of 8 inches and a breadth of 20 inches, but the usual dimensions are about 3 by 4 inches. The brackets may appear singly or in numbers, one above another. They may fuse at the sides, forming masses along the sides of logs or the roots of trees. There is usually a resupinate portion from which the fructifications spring and from which smaller brackets are sometimes produced beneath. The upper surface is slightly concentrically grooved, with occasional fine lines or striæ radiating from the point of attachment. The lower surface is smooth and consists of a layer of very fine pores, scarcely visible to the unaided eye. The most conspicuous visible character of the fungus is its brilliant color when fresh. The upper surface is a rich red-brown with a buff-yellow margin. As the fungus reaches maturity, alternating zones of red, brown, and yellow appear, which finally become less conspicuous as the fungus dries. When dry it is a more or less uniform yellowish brown or wood color, with concentric zones of darker color. The lower surface when fresh is a bright orange, which deepens to a reddish brown with age. This is more or less permanent in dried specimens, the color in old specimens being confined to the mouths of the pores. The substance of the context when fresh is firm fibrous and is easily broken. It consists of thin-walled hyphæ. The hyphæ of the pores in cross section give the appearance of a true tissue. This is a characteristic feature of the tissues of the group to which the fungus belongs and is the reason for the hard, horny, brittle condition of the pores when dry. A vertical section through the fungus shows two distinct layers. The upper or context layer is whitish yellow, the lower consisting of vertical pores at right angles to the upper layer, which is reddish brown. The color usually fades in old specimens from the pore layer, except at the lower surface. Sometimes there are more than one layer of these pores. This condition, however, depends upon the weather and the exhaustion of the substratum and is not typical for the species. When dry the edges of the brackets curl downward, and they are very hard and brittle. When resupinate, the edges of the broad flat plates curl away from the substratum and frequently fall to the ground.

The fungus is propagated by wind-borne spores and by vegetative mycelia in the form of strands or cords ramifying through the soil. Conidialike bodies were observed on felted masses of mycelium in cavities in decayed wood.

POCKET ROOT-ROT

The small fructifications of *Polyporus lignosus* in a dry state closely resemble another common and widely distributed species which extends into the Temperate Zone and is known under a variety of names. This species is *Polyporus zonalis* Berk. (Pl. V, A), and it is found on the same set of hosts. It never attains the size of *P. lignosus*, and its texture is usually more firm, but its structure as regards the appearance of the hyphæ in cross section is the same. Small dried specimens of both species are sometimes difficult to distinguish. There are certain characters, however, by which they may be known. When fresh, *P. zonalis* is not so brilliantly colored. The upper surface is concentrically grooved and covered with a hard crust when dry. It is usually of a uniform wood or brown color, sometimes alternating with pale bluish or chestnut zones. There is not the contrast in color between the pore and context layers shown in *P. lignosus*. Although *P. zonalis* is sometimes pink or flesh colored it fades to a uniform gray or dingy white or wood color. The most reliable means of distinguishing between the two species in the field is in the character of the decays produced. The rot of *P. zonalis* is differentiated, showing well-defined pits or pockets, usually arranged parallel to the wood elements in the rot area (Pl. V, A). In early stages of the decay these pockets may merely show in outline; later, however, the wood in each indicated pocket disappears, leaving a cavity. The rot of *P. lignosus*, as has been indicated, is uniformly white or yellowish and undifferentiated.

Polyporus lignosus is a parasite; i. e., it has the ability to attack living roots without the intervention of wounds or exposed dead wood. It continues to fructify, however, after the death of the host and may be found growing on all kinds of dead wood in the forest. It is a facultative parasite. *Polyporus zonalis*, on the other hand, is a wound fungus, depending upon a break in the bark or exposed dead wood to effect an invasion of its host. Under these conditions it has been found attacking the wood of wounds on living roots of Hevea and other jungle trees. Along a canal cut through the jungle near Para this fungus was found as a root rot on Hevea. The roots had been badly damaged by the workmen, with much dead wood exposed. The fungus had entered at these wounds and was causing a decay of the heartwood of the root. Near Riberalta in Bolivia the fungus was found causing a heart rot in the base of a young Inga species. A large open scar at the base of the tree with dead wood exposed was the means of entrance. Fruiting bodies appeared at this point. Thin sheets of mycelium with interlacing strands are also produced by *P. zonalis*. These sheets ramify over the substrata and through the surrounding forest litter. They are not conspicuous; the strands are delicate and seldom encountered. It is doubtful whether the fungus will be found of consequence on well-managed estates.

The sporophores persist indefinitely in tropical countries, and all infested materials on the estate should be promptly burned.

This fungus, under the name of *Polyporus rugulosus*, has been considered by Brooks the cause of a root disease of Hevea on the Malay Peninsula.

RED STRAND-ROT

The red strand-rot fungus (*Poria vincta* (Berk.) Cke.) was found fruiting on the lateral roots of living Hevea stumps at Colonia de Onteiro (Pl. V, B). The decay affected the lower half of the root and extended about 6 inches beneath the soil. At the root collar the decay had spread over an area of about 8 square inches and had caused shrinkage and death of the cortex, with checks in the outer bark. Smooth, tough, dark-red rhizomorphs were distinguishable as small irregular patches between the bark and wood. These rhizomorphs were of the color of dried blood, and in some cases were dark brown or black with age. They occurred chiefly as flat anastomosing bands of irregular breadth, becoming whitish fimbriate at their extremities. The fimbriate condition was more pronounced on the wood longest in decay and took the form of a thin white silky sheet radiating in a fanlike manner (Pl. V, B). These become brownish with age. The hyphæ may coalesce and re-form as red rhizomorphs.

In cavities produced by shrinkage of the wood the rhizomorphs become rounded and more cordlike. Cross sections of these strands showed an outer compact layer of deep-red thick-walled branching hyphæ of irregular dimensions, with conspicuous lumina presenting a pseudosclerenchymatous appearance. Deep-red cystidia of irregular shape and of a sclerotic effect were occasionally observed in this tissue. The outer layer surrounded a parenchymatouslike central core of hyaline thinner walled hyphæ of great irregularity in size and shape. Sometimes there were two layers of the hard red outer hyphæ separated by a layer of less dense and slightly yellowish tissue. Under the microscope the upper free surface of the rhizomorphs may be slightly tomentose.

These strands were also discernible in the irregularities of the bark beneath the subiculum of the fungus, but in no case either between the bark and wood or beneath the subiculum were they abundant. They rarely occurred on the outer surface of the bark not overrun by the fructification. Several collections of the fungus on dead wood of various trees had developed the rhizomorphs imperfectly, or they were entirely absent. Most of these collections, however, were past their prime, and the rhizomorphs, if present, were largely discolored or disintegrated. This fungus has been repeatedly collected in the West Indies and Brazil in recent years, and on the subiculum and substrata of some of the specimens remnants of these rhizomorphs still persist.

The under side of the mature fructification, which may be irregularly raised from the substratum, is smooth, horny, and of a dried-blood color. In a young growing stage the under side may be of a brighter red. Occasionally the outer layer of the wood is stained faintly reddish, becoming brownish with age. Faint reddish lines may irregularly penetrate the wood, or the stain may develop between two annual rings. The presence of the red color in the wood is but temporary, and it usually disappears altogether or remains as a faint rustiness. In diseased wood of long duration all evidence of a red color has disappeared. Since the red color in the wood is a temporary condition, it should not be used as a reliable diagnostic character for the species. The reason for this lies in the fact that a

false diagnosis may result by confusing the species with *Poria borbonica* or *P. albocincta*. These species always produce in the wood a highly characteristic and permanent red stain and may be present in wood without the development of fruiting bodies. Both species have been collected on the wood of Hevea, but so far only as saprophytes.

Poria graphica is another common species producing a red stain in the wood, but it has not been collected on the wood of Hevea. The species is abundant, however, on associate trees. The three species last named may also sometimes produce reddish mycelial strands. Since the development of this structure in *P. vincta* is not always evident, other means may sometimes be necessary to detect the presence of the fungus. The presence of the fructification, which has a different structure and color change from the other three species, together with the character of this rot and the usual absence of the red stain in the wood are to be considered in doubtful cases. The decay of *P. vincta* in the early stages is firm and slightly yellowish. In advanced stages it is soft and wet when in the ground, but white, light, and friable when dry.

The fructifications are entirely resupinate, as is the case in all members of the genus. The initial development is the formation of a thin yellowish white plate, with a whitish and slightly fimbriate margin. The pores as they first develop as a thin layer on the plate are yellowish white, and later pink. On maturity the pores become reddish brown and may or may not develop a slight cinereous or gray color. The pores are small, scarcely visible with the naked eye, and the layer they form over the bark is about 1 to 2 millimeters in thickness.

The pathogenicity of the fungus in the American Tropics and its probable economic importance must be left to future investigation. The species is common on jungle stumps and is found throughout tropical America. Since it was found decaying the wood of living roots of an unknown jungle tree and was collected on living roots of Hevea it may be expected to occur in plantations where original forest material is left in the area.

Poria hypobrunnea, a closely related species found and described by Petch on Hevea in Ceylon, is reputed to be the cause of considerable root-rot. *Poria hypolateritia*, a species closely related in some respects, is reported as causing one of the commonest root diseases of tea in Ceylon. The species occurs in Africa and probably also in the American Tropics.

GANODERMA ROOT-ROT

The disease caused by *Ganoderma amazonense* n. sp. is widely distributed in the Amazon Valley and occasions considerable root-rot in Hevea. It was first found decaying the roots of *Spondia lutea*, but in the main it appears to be more intimately associated with Hevea. It was found on the roots of this host at eight different stations. The causal organism described as *Ganoderma amazonense* does not agree with any known species of the genus. (See p. 84.)

The white spongy decay is without any special diagnostic character. At first firm, the decay becomes soft and spongy, and in

the submerged roots it is wet and plastic. It may extend to a considerable depth in the roots and upward in the trunk for a distance of a foot or more above the root collar. The affected roots may appear more brown than in the normal state. When the entire root is decayed the bark may be readily removed, showing a whitish mycelial development on the under surface. After the brace roots are decayed the tree may be blown over. Two trees in a leaning condition were affected by this fungus.

The fungus usually fruits at the surface of the ground in the root crotches or on roots that are exposed. In one case the sporophores were produced on the trunk some distance above the root collar. The entire side of the trunk was decayed for a distance of 2 feet above the ground.

The sporophores are generally irregular brackets, sometimes with a false lateral stem (Pl. VI). The upper surface is brown incrusted, smooth, and concentrically zoned. The margin is white when in a growing condition. The pores are white when fresh and do not change in drying. The context of pileus is whitish next the crust and light brown below.

This fungus is in no sense parasitic but enters the tree through wounds. It is not expected to attack young trees, but will be found on trees that have attained considerable age and size or trees that have developed considerable heartwood in the roots and trunk. Although apparently more intimately associated with Hevea, the fungus undoubtedly will be more abundantly found on jungle trees when the subject is studied in more detail.

BLACK LINE-ROT

The black line-rot fungus (*Ustulina zonata* (Lev.) Sacc.), the cause of a serious root and stem decay in the Orient, was found associated with cankers in the root crotches of Hevea at three different stations. Since the presence of no other fungus could be demonstrated in relation to the cankers it is believed that they were caused by this Ustulina. The cankers had apparently originated on the sides of the lateral roots and had spread to the base of the tree, affecting a strip on the main trunk about a foot above the root collar. The area affected was in each case still partially covered by the dead bark, but the wood was rotted, checked, and shrunken so that it could be easily picked out with a knife, leaving a cavity. The solid but dead wood immediately surrounding the cavity was invaded transversely and vertically with broad conspicuous zigzag black lines. (Pl. VII, A.) Sometimes these lines when cut appeared as circles or parallelograms and inclosed an area of brown wood. This zone joined with the living wood of the tree. The bark to the right and left produced latex when cut, but the living bark above the canker appeared dry and produced no latex. The bark covering the zone of black lines bore the fructifications of the fungus in various stages of development. On the root at the surface of the ground small black nodules were present. These were sterile and were evidently imperfectly developed fruiting bodies.

The normal fructifications were congregated at the root collar. They consisted of broad flat plates with irregular surfaces and were loosely attached to the bark (Pl. VIII, A). The young fructifica-

tions appear on the bark as small protuberances, which are white when in a growing condition. These projections begin to expand at the margin, and eventually broad flat plates some 4 or 5 centimeters in diameter and about 2 millimeters thick are developed and are attached only at the point of origin. Most of the black incrusting fungi of this group are attached to the substratum over their entire lower surface and are consequently more firmly fixed. When several plates develop in close juxtaposition their margins fuse and a crust may be formed over a considerable area. Each individual plate is usually concentrically zoned, so that the compound plate appears to be made up of a series of circular disks. With age these plates may become undulated or corrugated as growth ceases. The edges may remain very thin. At first white or gray, the plates on weathering or when old become black. When fully mature the plates are white internally and usually show a single layer of elongated or oval cavities (perithecia) (Pl. VIII, A) filled with a plastic content. When old the cavities become empty and the tissues turn black and are very brittle.

The flat plate with concentric zones is not always a constant character of the fungous fruits on uneven surfaces. The fructifications may be very irregular, without zonations, and may resemble other species of the group. *Ustulina vulgaris* (Pl. VIII, C) of the Temperate Zone is said to be identical with *U. zonata*.

The upper surface of the crust is dotted with numerous small black points (ostiola). Each of these corresponds to a cavity below and is the opening through which the spores are expelled. In the early stages of development, before the cavities are formed, the surface is covered with numerous conidial spores borne on short erect stalks. These spores are the first to be developed and, since they may be carried about by the wind, serve as a ready means of distributing the fungus. The production of conidia soon ceases, and the surface becomes hard and smooth with the exception of the small punctations which open into the cavities. The second spore formed is produced in asci lining the walls of these cavities. These spores are dark colored and spindle shaped, and they are expelled through the ostiola. During damp weather they may collect in the form of a black deposit on the surface of the crust.

The progress of the disease appeared to have been very slow. At the time of study the edges of the canker were beginning to put out healing tissue. The internal activity of the fungus appeared to be somewhat diminished, in that the line of demarcation between the infected and the sound wood was sharply defined. The cortex of the infected roots for several inches below the canker was of a bluish black color. Mycelial fans bounded by black lines were present on the under surface of the bark or on the wood of the root. The latter condition appears to be more or less characteristic for the disease, not having been noted in other fungi of this group on Hevea. The presence of black lines in the wood, however, is misleading. These lines are common to a large number of Pyrenomycetes.

It is unlikely that the fungus can enter the tree without the intervention of wounds. These are more likely to be at the base of the tree. Although one case was noted where tapping wounds

were infected some 3 or 4 feet above the ground, the fungus is primarily confined to the roots.

The fungus spreads to Hevea from jungle stumps and logs. It is obviously necessary to free an estate of these sources of infection and to remove Hevea stumps and logs after thinning. Once the disease is detected the areas of infection on individual trees should be divested of the affected tissues and the cavity thoroughly treated with coal tar. This method is usually effective in the treatment of such fungi and prevents the development of the fructifications. Infected trees of long standing should be removed.

All the collections of *Ustulina zonata* were made from trees growing on high well-drained soil. Whether this is a condition favorable to the development of the fungus further studies will determine. It is to be remarked, however, that *U. vulgaris*, the form which in the Temperate Zone is the cause of root-rot in various trees, especially maple, is usually associated with dry sites.

Another species of Ustulina found on Hevea roots differed in several details from the type form of *U. zonata*. It was found on living roots of a Hevea stump. Not until it is possible to make more extensive studies can its identity be determined. It is chiefly characterized by a conspicuous white thick subiculum (Pl. VIII, B). It is described in the mycological section of this bulletin (p. 94).

On dead wood of wounds of different kinds, chiefly fire scars and areas of the trunk killed by borers, three species of related genus are occasionally observed. Their action and its effects upon the tree are similar to those of *Ustulina zonata* except that they do not appear to encroach upon the living parts of the tree as vigorously as this species. These fungi are *Kretzschmaria coenopus* (Pl. IX, A), *K. lichenoides* (Pl. IX, B), and *K. apoda* (Pl. IX, C). The mature fructifications may be mistaken for Ustulina, but they may be distinguished by their structure and mode of development. Instead of developing as a flat disk attached at one point several anastomosing stalks appear. These broaden out at their apices into flattened heads, which later fuse with each other, forming cushions the surface of which is made up of small polygonal areas. These cushions are from 1 to 5 centimeters thick. When broken apart the anastomosing stalks and individual heads are exposed. The ostiola, or openings to the cavities or perithecia embedded in the head, are visible on the surface. The young interlacing stalks and likewise the immature cushion are grayish white, but the entire structure becomes black and brittle when mature. The fungus produces black lines in the wood, but these are usually not as conspicuous as is the case in Ustulina.

Kretzschmaria apoda (Pl. IX, C), found once on an old tapping wound, is distinguished from the other two species by the formation of larger polygonal areas and a more robust structure in general. It is a wound fungus and was confined in this case entirely to the dead wood.

SPHAEROSTILBE REPENS

The fungus *Sphaerostilbe repens* Berk. and Br., originally reported from Ceylon in 1907, which has been repeatedly considered the cause of a root disease of Hevea, tea, and other plants in the Orient, has not been found for a certainty on Hevea in the Amazon Valley. A diseased root of Hevea was examined which showed evidences of the

disease, but the fructifications of the fungus were not found. Between the bark and the wood broad flat reddish black bands or rhizomorphs were present. These were pressed to the surface of the wood and in some places had been followed by borers. The outer layers of the wood were of a blue color, but there was an absence of the foul smell attributed to the disease in the East. There was no evidence that the root was infected by Ustulina or by *Poria vincta*, which produces red-colored strands.

On the other hand, a closely related fungus was common on Hevea and was found to cause infections in old pruning wounds and tapping cuts. This fungus is *Stilbum cinnabarinum*, as its conidial stage is called. The perithecial stage *Megalonectria pseudotrichia* was more common. Around the edges of the wounds the conspicuous small smooth red stalks with apical pink or red conical apothecia were produced in great numbers. The apothecia were especially abundant on the bark of Hevea which had been scorched by fire. The fungus was also present on the tops of living Hevea stumps, affecting the formation of the callus at the edges.

Sphaerostilbe repens may be distinguished by the fact that the conidial and perithecial stalks are hairy, at least for a part of their length. The fungus apparently is not an active parasite and is liable to follow adverse conditions of growth. Van Overeem considers it mostly saprophytic, especially on swampy, low, wet land. In this class would also fall *Stilbella heveae*, described by Zimmerman on dead branches of Hevea in the Orient.

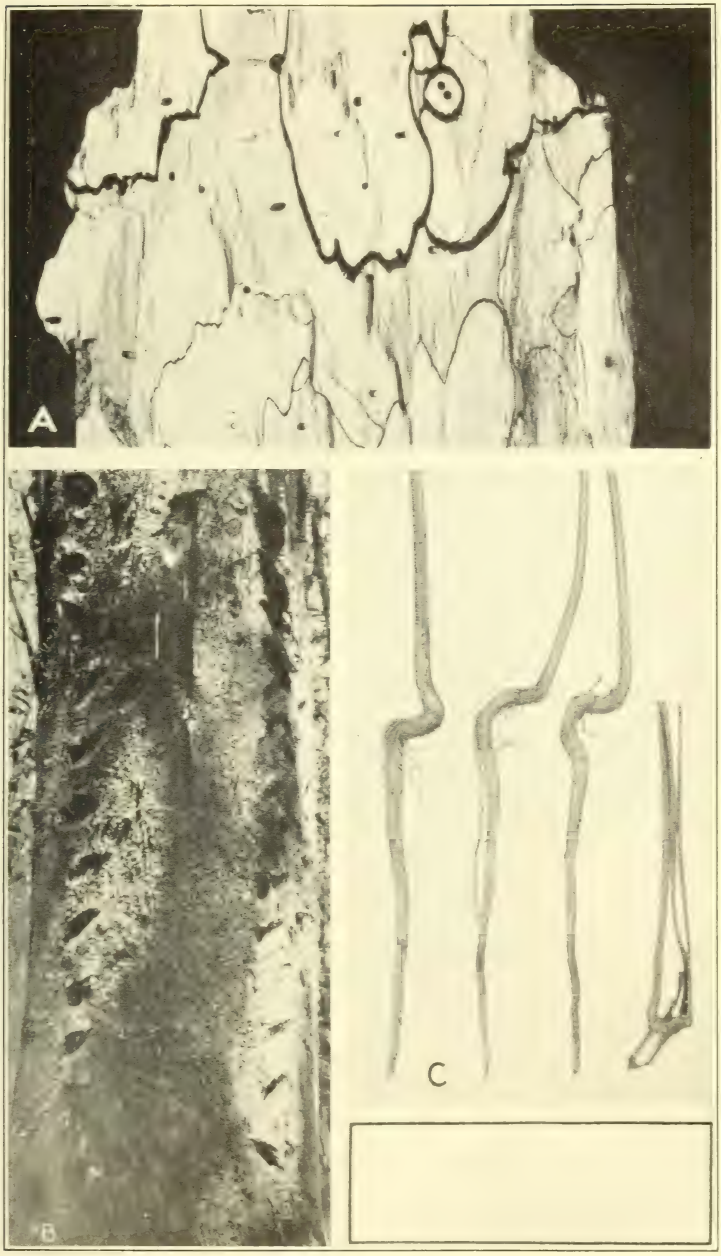
OTHER ROOT FUNGI

During the present investigation a large number of fungi have been collected from the roots of various jungle trees felled in clearing operations and on decaying roots of cacao, caju, and other of the more permanent crops frequently associated with Hevea in small plantations. The repeated occurrence of a number of these fungi on decaying roots both of Hevea and associated crops intermingled in a rich wet humus soil and also on the drier sites introduces a pathologic condition which is to be expected under the circumstances. Only those which appear to be potential pathogens will be discussed. In this group will also be included the fungi which act upon the dead tissues of the living trunk. The destruction of the dead though mechanically important wood of the tree leads eventually to a reduction of vigor and to windfall.

TRAMETES CORRUGATA

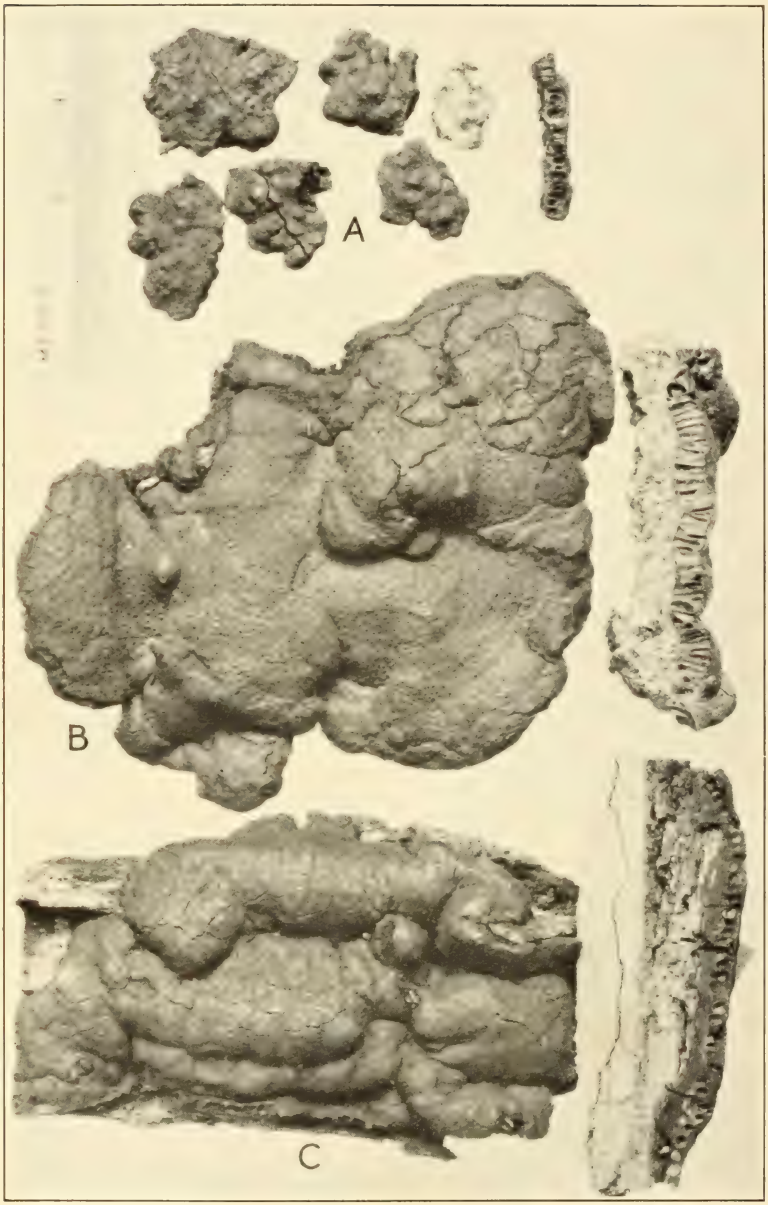
One of the most common wood-destroying fungi in the Amazon Valley is *Trametes corrugata* (Pers.) Bres. It attacks the wood apparently of all forest trees. It is also a wound fungus on Hevea. It causes a butt rot, entering the tree through various injuries to which its base may be subject. The decayed wood may be entirely broken down or tunneled out by white ants, causing the tree to be hollow at the base (Pl. X, A).

The fructifications are easily recognized by the reddish brown upper surface and white margin (Pl. X, B). It is frequently thin and flexible. The pores on the under side are yellowish white and irregular in shape. Internally the fungus is white.



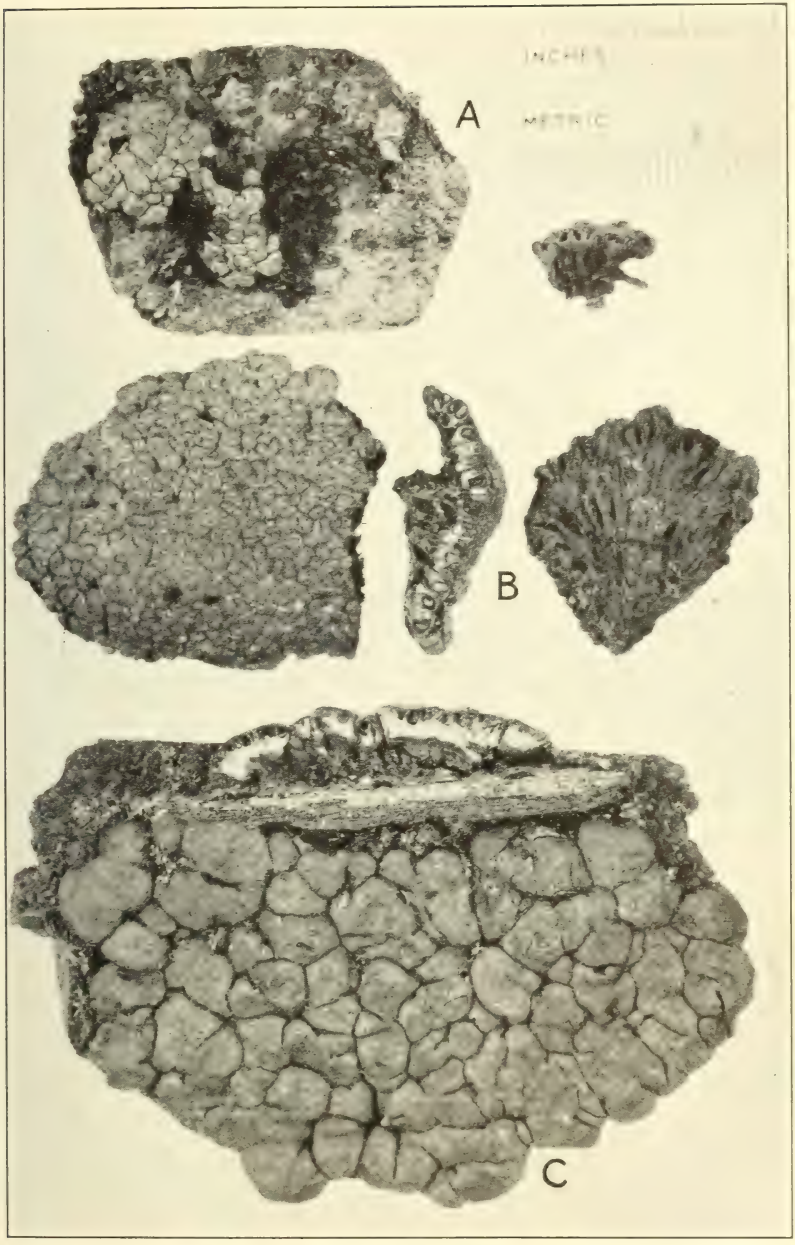
DISEASES OF HEVEA

A, Black lines in the wood caused by *Ustulina zonata* (natural size); B, disease of tapping wounds followed by insects; C, seedlings showing bent condition of the stems and lateral development after injury to primary shoot (natural size)



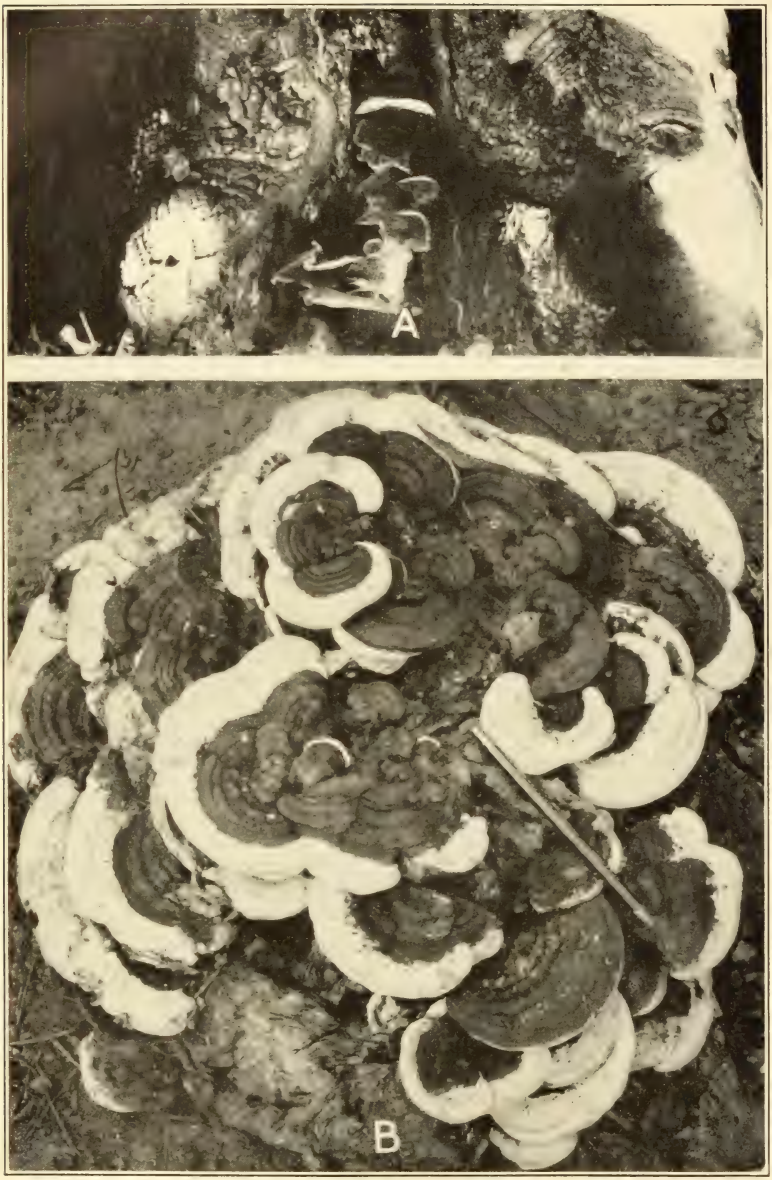
FRUCTIFICATIONS OF BLACK LINE-ROT FUNGI

A, *Ustulina zonata* on Hevea roots; B, *U.* sp. on Hevea; C, *U. vulgaris*



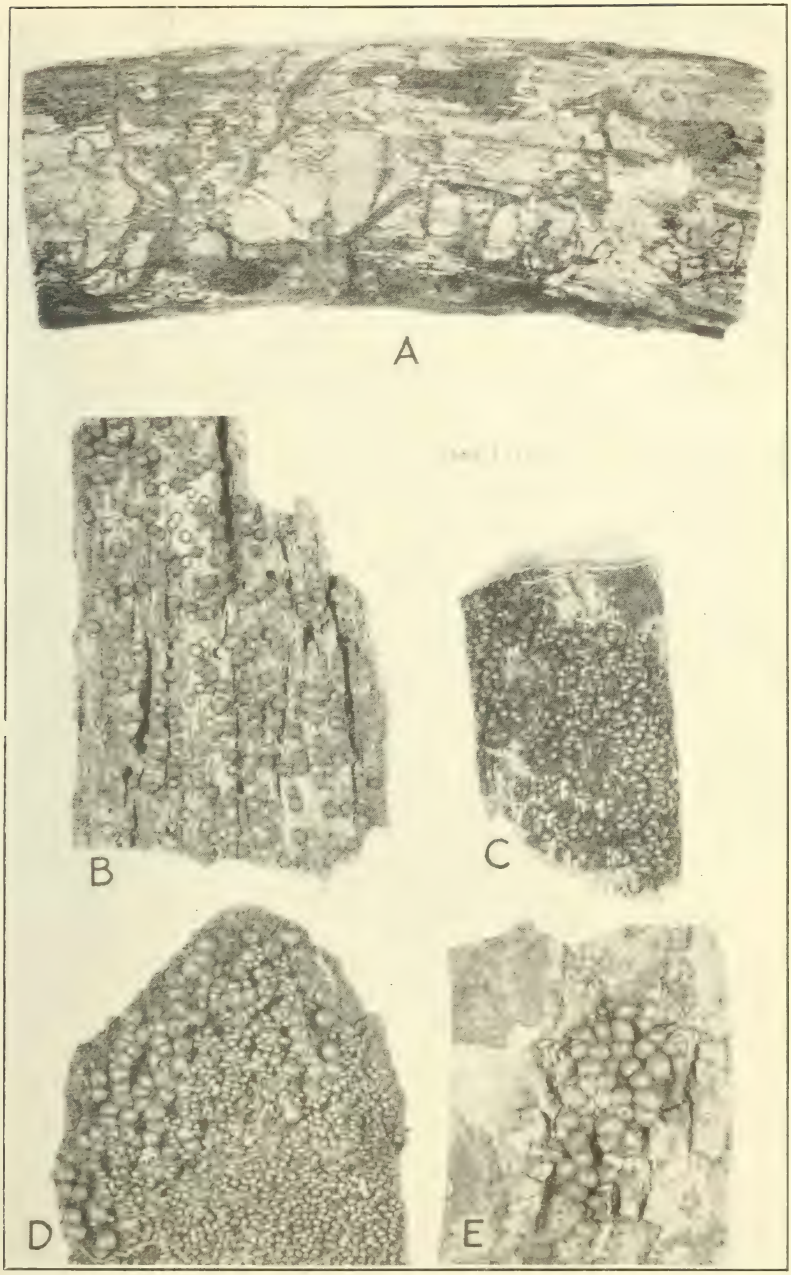
FRUCTIFICATIONS OF KRETSCHMARIA ON HEVEA

A, *Kretschmaria coenopus;* B, *K. lichenoides;* C, *K. apoda*



FRUCTIFICATIONS OF TRAMETES CORRUGATA ON HEVEA

A, On old basal scar, the wood having been tunneled out by white ants; B, on stump, showing character of the upper surface



FUNGI ON HEVEA AND CACAO

A, Mycelial strands of *Rosellinia bunodes* on Hevea, with some insect work; B, *R. subiculata* on Hevea; C, *R. australis* on cacao; D, *Schizostoma* sp. (small) and Rosellinia on dead bark; E, *R. puiggarii* on Hevea

DIPLODIA THEOBROMAE ON LAST INTERNODES OF HEVEA TWIGS

(× 2)

This fungus is not of economic importance except in cases where large areas of heartwood are exposed. This is a condition that would rarely exist on well-regulated estates.

TRAMETES FLOCCOSA

A single case in which the fungus *Trametes floccosa* Bres. was apparently responsible for root decay in Hevea was observed near Villa Murtinho on the Madeira River. A large tree which had been left in the open after clearing away the jungle had been recently overthrown by the wind. The lateral roots were pulled from the soil on one side and were badly decayed. The taproot broken off some 2 feet below the surface was rotted. The rot extended upward in the trunk for a distance of 3 to 4 feet and was exposed by the splitting of one side of the trunk. The overthrow of the tree must undoubtedly be attributed to the decay in the roots. Fructifications of the fungus had recently developed directly from the split surfaces of the decayed wood. Under the circumstances the fungus may be considered the cause of the decay. The means by which the fungus had entered the tree could not be determined.

The fructifications of the fungus are characterized by a thick soft light-colored punky context, a smooth brownish or black slightly encrusted surface, and small round pores having a texture harder than the context. The spores are elongate-elliptical, smooth, and measure 12 to 14 by 5 to 7 μ. The species has not been heretofore reported from the American Tropics. It is common in Ceylon and Africa. The decay is light yellowish in color and somewhat firm.

BROWN-ROOT DISEASE

The fungus *Fomes lamaoensis* Murr., the cause of much damage to the roots of Hevea in the East, was not found on Hevea in the Amazon Valley. It has been reported from the West Indies, but the specimens on which the report was based are to be referred to *F. pachyphloeus*, a closely related species.

GANODERMA AUSTRALIS

Ganoderma australis was found once as a wound fungus on Hevea.

ROSELLINIA DISEASES

Among a number of ascomycetic fungi collected on the roots of Hevea, either of dead stumps or trees or on the deadwood of open wounds on roots evidently caused by mechanical injury, were species of Rosellinia. This group has received considerable attention in recent years, for the reason that some of the most serious diseases of economic crops in the East Indies and the West Indies are caused by these fungi. Although no direct relation between the species found on Hevea and the diseased condition of the roots has been determined, the fact that they are present and were also found on the roots of associate crops where they exhibited parasitic action makes it desirable to record their occurrence for future reference.

As is well known, some of the most serious root diseases of Hevea arise from the spreading of a fungus from decaying stumps of associated crops or jungle stumps. The disease spreads chiefly through the soil by means of vegetative mycelia following along decaying roots and other plant materials. In the case of several of the Rosellinia species no adaptation to a particular host has been observed. They seem to be able to attack and kill the roots of most of the plants encountered.

The fungus *Rosellinia bunodes* (B. and Br.) Sacc. has been reported as the cause of a stump rot or a black root disease of pepper, tea, coffee, and several species of forest trees in India. In Ceylon it attacks tea and hibiscus. In Porto Rico it occurs on coffee and associated plants. It was found by South on limes in Dominica and on camphor and *Castilloa elastica*, the Central American rubber tree, in Grenada. Nowell reports this fungus on a large number of fruit trees, root crops, and various native shrubs in Dominica and St. Vincent. In the Amazon Valley it was found on the roots of cacao and Hevea.

The black root disease of Hevea reported by Van Overeem and also by Steinmann in Java is attributed to this species.

The mycelium of the fungus forms fine black slightly flattened strands, forming a network over the surface of the roots and beneath the bark (Pl. XI, A). These strands may later extend to the parts above the soil, where they spread out, forming purplish black velvety patches. The mycelium penetrates the wood along the medullary rays and later invades the larger cell elements, filling them completely. In cross section the dark-colored mycelium is seen as black dots and radial lines. This appearance in the wood is characteristic for the species.

The conidia are borne on the superficial patches. The perithecia follow the production of the conidia and are partly embedded in the velvety layer. They are characterized by superficial scalelike warts, more or less concentrically arranged.

The species *Rosellinia pepo* Pat. was not found on Hevea, but was collected on the roots of cacao associated with Hevea in small plantations around dwellings. Since the species from its known activities in the West Indies may be expected to attack any plant introduced on recently cleared land it is here briefly described.

The mycelium of this species is distinctly different from that of *Rosellinia bunodes*. Instead of forming black strands the mycelium develops white fan-shaped or stellate patches between the bark and the wood. On the surface of the root the mycelium develops a dense smoky gray layer, which in later stages becomes black. It advances above the surface of the soil and forms an enveloping layer around the base of the stem. The growing margin is of a light-gray color, but it becomes brown or black on cessation of growth. The mycelium penetrates the wood in the same manner as that of *R. bunodes*, but since it is white it is invisible until after long exposure.

The conidial fructifications are developed in great numbers on the black mycelial layer above the surface of the soil and are composed of several vertical parallel hyphæ in the form of a bristlelike stalk. These hyphæ spread out at the apex, and the spherical 1-celled conidia

are borne laterally near their extremities. The perithecia are developed on a dense carbonaceous layer at the surface of the soil. The wall of the perithecium is slightly roughened, but soon becomes smooth, and is shiny after long exposure.

Another species of Rosellinia found on dead roots in contact with those of Hevea and apparently causing disease is *R. subiculata* (Pl. XI, B). *R. australis* is common on dead roots of cacao (Pl. XI, C); *R. puiggarii* (Pl. XI, E) was found on Hevea roots and a species of Schizostoma (Pl. XI, D) on various dead roots in plantations. These species should be carefully studied.

STEM AND BRANCH DISEASES

PINK DISEASE

The pink-disease fungus (*Corticium salmonicolor* Berk. and Br.) is widely distributed in the American Tropics, being recorded from Porto Rico, Trinidad, Dominica, and St. Lucia. It is common on the stems and branches of cacao, and is recorded on grapefruit, lime, orange, oleander, pigeon-pea, and amherstia. In the Orient the fungus attacks a great variety of hosts. Butler states that it has hosts belonging to the most diverse families, a range perhaps wider than that of any other tropical parasitic fungus yet known, and he records it on 41 different economic hosts. Petch states that in Java 141 different species of plants are known to be attacked by it.

In the East the different hosts are not equally susceptible. Experiments have shown that the fungus readily passes over from one species of host to another, but there is no indication that biological races exist. Hevea, Castilloa, and Ficus are especially susceptible to the disease. Vincens records a species of Corticium found at the base of shoots of Hevea which he suggests might be *C. salmonicolor*. He states that it appears to be harmless. Later, the same author records the fungus on Hevea in the Amazon Valley.

During the present investigation the fungus was found on dead branches of Hevea attached to the living tree; but there was no evidence that it was acting as a parasite, since there was no extension of the fungus beyond the branch collar. It is possible, however, that its activities might have been arrested after the death of the branches or by drought. Its appearance on citrus was of a more decisive character and was the cause of considerable damage.

The fructifications of the fungus on Hevea generally originate in the forks of the branches and form pink or rose colored incrustations on the bark. These incrustations become whitish or completely bleached with age, and the surface cracks into fine lines more or less at right angles to each other. Like many species of the group, both the mycelium in the wood and the fructification are resistant to drying. The structure consequently revives during rainy weather, at which time spores are being produced, and it may then again become pinkish or waxy.

The fungus may appear in any one of four different stages. The typical or Corticium stage here described was the only one observed on Hevea. On lime and cacao all stages were found. At the margins there is frequently an extension of the mycelia in the form of fine silky hyphæ which form a thin silvery white semitransparent

sterile layer over the bark, or this layer may be formed in small patches not connected with the more mature parts. This stage may be followed by the appearance of small sterile pink or white pustules arranged in parallel rows in the cracks of the bark. This stage may appear over the surface covered with the thin white film or on areas not previously fruiting. A third stage appears in the form of irregularly rounded or elongated orange-red bodies. These are at first embedded in the cortex, but later rupture it and appear singly or in clusters on the surface. These bodies when they emerge resemble species of Nectria and consist of masses of spores. This spore-bearing stage was originally considered to be a distinct fungus and was described as *Necator decretus* Mass. It has been shown recently, however, that it is only a phase in the life history of the same fungus and is a rapid means of propagation. This stage is present on the material from the Amazon Valley. Nowell states that so far it has not been recognized in West Indian examples.

Inoculation experiments in the East have demonstrated that the fungus is capable of infecting its host directly through the uninjured bark; hence it is not a wound fungus, though it appears that infection may take place through wounds.

The type of injury caused is usually first shown by the yellowing of the leaves of the parts above the infection. The infection encircles young stems or spreads from basal infections of branches to others at the point of union, and if complete girdling results all parts above the canker die. If the fungus is arrested by dry weather, the bark over the affected area cracks, causing the formation of open wounds.

The vigor of the fungus is known to depend largely on moisture and exposure. Hence, the usual measures for reducing the ravages of the parasite in plantations have been to regulate spacing, to provide drainage, to avoid intercrops that serve as hosts, and to keep trees in a high state of vigor. Direct control would require that all infected branches be cut out and burned. The branches should be cut several inches beyond the visible zone of infection. This is necessary, for the reason that in practically all fungous infections of this nature the mycelium has advanced considerably beyond the immediate cankered area. All branch knots and larger wounds on the main stem should be thoroughly saturated with coal tar. Spraying uninfected trees regularly after rains may prevent infection by newly distributed spores.

DIE-BACK

The die-back fungus (*Diplodia theobromae* (Pat.) Nowell) is very widely distributed in the Tropics and has been reported on a great many different kinds of plants from the West Indies, the East Indies, Oceania, South America, Africa, and southern Asia. The fungus was first reported from the American Tropics by Howard in 1901. He found it causing a die-back on cacao in Grenada.

During the present investigation it was found on the stems and fruits of cacao and mango under circumstances implying parasitic tendencies.

As a saprophyte it occurred on a great variety of substrata. Dead stems of Hevea thrown in moist places were found to be covered with the fructifications of the fungus. It was especially common on dead stems of the witches'-broom on cacao. On the immature fruit of cacao the fungus was invariably present, covering the entire surface with a dark-brown or black sooty layer. Immature Hevea pods gathered one day and rolled up in oiled bags would be covered with the fungus three days later. The fact that the fungus as a rule enters the host only by way of injured branches and that it rarely takes advantage of the mutilation of the tree in tapping as at present practiced indicates a tendency to confine its activities to those parts of more recent development. On tapping wounds the fungus was first observed on the dead cortex around the cut, but had not invaded the living tissues or stained the wood. In later discovered cases the fungus exhibited a greater degree of parasitism, the affected area extending below the cuts for several centimeters. The dark-colored mycelium was present in the wood, forming narrow dark parallel lines similar to those commonly called "black thread" and referred to Phytophthora as the causal agent.

La Rue and Bartlett have obtained results from inoculations with Diplodia which have led them to state that infections in the wood produce black streaks and that they are not distinguishable from the black-thread disease usually attributed to Phytophthora. In the latter the dark lines as a rule are due to the infiltration of the wood with substances from the seat of infection and do not contain mycelia.

Diplodia was first observed on Hevea as a saprophyte on pruned branches on living trunks injured by fire, on fruits of the previous year killed by Phytophthora and still hanging to the tree, on stubs of improperly pruned branches (where it apparently acted as a wound fungus), and on twigs that were being weakened or killed by repeated defoliation or infection by *Dothidella ulei*. The last condition in the vicinity of Para seems to be the initial cause for the attack of the fungus on Hevea. Other fungi, however, were occasionally found associated with it. (See "Fungi reported on Hevea," p. 83.)

The general aspect of infected trees is the presence of dead terminal twigs. One such tree, about 10 feet high, in the edge of the jungle near a small plantation in the vicinity of Para was carefully examined. Ten different twigs were dead, and the disease had extended downward to the first lateral branches, which in turn were either dead or in a languishing condition. The wood of the infected stems was blackened by the reflected color of the dark-gray or brown mycelium, after the manner of Ceratostomella species in the sapwood of timber trees. Examination of the wood ahead of the blackened areas shows the mycelium to have extended beyond the zone of evident infection from 1 to 4 inches and to be colorless. For this reason, as Petch has pointed out, discolored wood does not indicate the most forward region invaded by the fungus. The bark on the infected branches dries and cracks, exposing a dark film on the surface of the wood.

In the case of infection on a pruned stub 2 inches in diameter projecting some 4 inches, it was observed that the fungus had progressed

8 inches below and 3 inches above on the main trunk. The area of evident infection both above and below was not more than the width of the branch. The cortex and wood were discolored, with a slight exudation of latex at the margin of the zone of infection. With the means at hand it could not be determined how deep the discoloration extended into the wood, but that it was discolored to a considerable depth was evident.

The fructifications of the fungus show great variability, depending upon the kind and condition of the substratum. This has resulted in a multiplication of names. If the observations of Bancroft, which are concurred in by Vincens and others, are to be accepted, the life history of the organism includes a conidial and an ascigerous stage. The latter, however, has not been definitely determined.

The conidial stage appears as small black spherical bodies (pycnidia) embedded in the bark on dead twigs (Pl. XII). These may be scattered more or less uniformly on young twigs and leaves or congregated and confluent on older stems, especially in cracks in the bark. The pycnidia are at first invisible, but their location in the bark may be distinguished by the slightly raised epidermis. When aggregated on old stems or on pods they are more conspicuous, especially during damp weather when the spores are being expelled. When cut across by shaving off the outer bark they appear as small black circles with white centers.

The oval 2-celled spores, white when immature, are extruded in immense quantities and collect over the surface of the twigs as a sooty layer. This is the condition in which the fungus is generally found on dead substrata on the ground. Sometimes in very damp situations fallen twigs appear whitish. This is due apparently to the expulsion of immature spores. Petch records a condition of the fungus on tea roots in which black cushions of hyphæ or spores burst through the bark and are surrounded by a narrow white fringe on which minute hyaline spores are borne.

Although the fungus is widely distributed, it apparently is of little consequence. If proper precautions are taken to reduce conditions favorable for its development, little damage will result.

BROWN-FELT COATING OF STEMS

The stems of Hevea seedlings and the smooth bark of young trees are occasionally incrusted with a thin loose velvety or felted mycelium (*Septobasidium* spp.), which in some stages of development is very conspicuous (Pl. III, B). The layer is seldom more than 3 millimeters thick and varies in color from a light slaty brown to dark brown, purple, or smoky black. The layer, when examined, will be found to have a most peculiar structure, which will readily distinguish it from that of all other fungi. A thin layer first forms over the smooth bark, and from this arise a great number of erect brown simple or branched filaments. These terminate in another continuous layer, and the process is again repeated until in some species a structure of five or six stories may be developed. The two-storied arrangement is most common. In some species the continuous layers are not distinctly separated by columnar bristles, but con-

sist of alternating loose and densely woven hyphæ, with a smooth, hard outer crust.

Several species of Septobasidium are found on the stems and branches of Hevea, but the specimens collected in most cases were sterile or immature and could not be determined.

One species commonly occurred at the base of young seedlings and extended below the surface of the ground. Its structure distinguished it from certain Hypochnus and hyphomycetous forms of similar habit.

Another species was characterized by the formation of a five to six storied structure, each continuous layer separated by branched septate filaments. Each layer is plainly distinguishable to the unaided eye. This fungus frequently covered the stems of young trees for a distance of a foot or more. When the outer slaty gray to sooty black layer flakes off in patches the stem presents an unsightly appearance.

A species found once forming a small patch on a Hevea branch was distinguished by its sooty gray or mouse-colored felty structure of loosely woven hyphæ without the usual pillared layer and its velvety surface. The species may be referred to *Septobasidium fumigatum*.

The fructification of a species was collected by C. D. La Rue on Hevea at Cobija, Bolivia, which differs from the spongy velvet forms above mentioned. It resembles the thallus of an incrusting lichen. It is dry, hard, and leathery, honey-yellow in color, and is divided into many narrow reticulate segments at the margin. The dense outer or fruiting surface is separated from the compact basal layer by only a slightly less dense middle layer. This species is referable to *Septobasidium frustulosum*.

The species of Septobasidium ordinarily are epiphytic on the living bark. It has recently been determined that some species at least are associated with colonies of scale insects which are killed by the fungus after the manner of the entomogenous fungi to be later described. In India and Ceylon certain species after destroying the insects penetrate the cortex of the tea bush and kill the plant. Other parasitic species are reported from Japan on acacia, mulberry, and tea. *Septobasidium frustulosum* causes a serious disease on stems and branches of ash in Mexico.

With the exception of the species found at the base of seedlings which appeared to cause a slight swelling the various forms observed in the Amazon Valley on Hevea were epiphytic. No evidence of penetration was noted. If any ill effect results it is due to suffocation of the parts overgrown by the fungus.

CLARET-COLORED CANKER

The disease known as claret-colored canker, referred both to Phytophthora and Phythium and reported to be destructive to Hevea in the East, was not found in the Amazon Valley during the present investigation. Several small cankers originating in tapping cuts and on untapped trees which could not be referred to the diseases elsewhere described were examined. Although some of the characters associated with claret-colored canker were present, those by which the disease is best known were absent.

According to the reports of eastern investigators this disease exhibits no marked external characters. An exudation of a reddish or purplish colored liquid is sometimes present. The affected area beneath the bark which at first is yellowish gray later becomes claret colored, and it is bounded by a black line.

Akers records a disease of the bark common to Hevea in the Amazon Valley as a decay of the latex cells on untapped surfaces. A copious exudation of latex is followed by a decay of the surface bark, which affects the bast and finally extends to the wood, rotting away the trunk and killing the tree.

HORSEHAIR FUNGI

The small hairlike mycelia of certain species of Marasmius (*M. sarmentosus* Berk. and *M. equicrinus* Muell.; Pl. III, C) occasionally overrun the stems, twigs, and leaves of seedlings in low wet ground. The appearance is somewhat like that of long coarse brown horsehair; hence the name. A similar condition is recorded in the East and appears to be quite common on rubber, tea, and many jungle plants. This mycelium was observed several times on rough bark at the base of young rubber trees as well as on seedlings from 2 to 3 feet high. On low jungle plants among swamps the mycelium was sometimes very conspicuous, forming tangles of considerable extent. In one case the leaves of a seedling were so thoroughly entangled with this mycelium that the young leaves developing later were ill shaped and deformed.

In the most pronounced cases observed the appearance of plants was as though they had become entangled in a mass of horsehair. The strands in most cases had their origin at the base of the plants and could be traced outward, over and through the forest litter. That the growth on rubber in such cases was purely accidental was evident from this fact. When not connected with the ground the filaments on leaves or on the bark of mature trees exhibited no common point of origin but ramified promiscuously in all directions. The filaments are rarely appressed to the substratum throughout their entire length, as is the case in the gray thread-blight, but they are attacked at intervals by small irregular mycelial pads consisting of small hyphæ of a lighter color than the cords and may radiate outward from the common base. These holdfasts adhere very firmly to the epidermis of the leaf or young stem. The cords may break before the pads will pull loose. The epidermis on the leaves is usually discolored at the point of attachment, but the mycelium has not been observed to penetrate the tissues of the leaf. The fungus obtains its nourishment from dead substrata.

The fructifications were rarely found on the aerial cords and then only in the dampest situations. At the base of seedlings or on the forest litter the fructifications were sometimes abundant. They spring directly from the cord, varying in distance from each other from a few millimeters to several centimeters. The fructifications are of the small mushroom type, with delicate or tough membranous semitransparent pilei set on stalks of the same size and color as the cords. The gills are widely spaced and correspond to radiating grooves on the upper surface. The color of the pileus varies from whitish gray to brown, according to the species.

In no sense do these small mushrooms derive their nourishment from the rubber plant. They are epiphytic and may be disregarded in plantation work on a large scale.

WHITE THREAD-BLIGHT

The stems and leaves of young rubber trees in dense parts of the jungle were occasionally found overrun with a mycelium (*Marasmius* sp.) in the form of white coarse-branching strands. The branches of a young tree about 4 feet high were observed in one instance to be completely overlaced with these strands. The strands extended to the twigs and spread out fanwise over the under side of the leaves, matting them together and causing them to turn brown, fall from the twigs, and remain suspended by the mycelial threads. The mycelium was entirely aerial, and in no case either on Hevea or on other jungle plants was it observed to take its origin from the ground. Developing on the branches first, the mycelium spreads to the leaves. The strands, composed of thick-walled hyphæ, branch at varying angles and are of a more or less uniform diameter on the woody parts of the plant. On the under side of the leaves the strands become more finely divided and cover the entire surface with a thin cobweblike layer, which later becomes mealy. The layer in this stage does not readily separate from the leaf. That part of the leaf covered with the mycelium soon loses its green color, turns brown, and checks transversely. If the entire surface is affected the leaf falls and may start new infections if it lodges in the foliage. The fructifications of the fungus were not observed. On fallen leaves of Inga affected apparently with the same fungus, fruiting structures of a species of Marasmius were observed, but they were too immature for determination. There was no invasion of the tissues of the host. The mycelium could be pulled from the epidermis; hence the fungus is apparently epiphytic. The damage results from a smothering of the twigs and leaves.

Petch has described two forms of white thread-blight on tea in the Orient. One is said to be parasitic, the organism not yet having been determined; the other is epiphytic and is referred to *Marasmius pulcher*. It would appear that both forms are known to occur on Hevea.

The damage from white thread-blight is not likely to be of consequence. Only in crowded seedlings would the blight be expected to appear, and the condition favoring its growth can be easily corrected.

Five different forms of these hairlike mycelia were observed. Three were of the polished smooth-cylindrical type and exhibited considerable tensile strength when pulled from the plants. The most common was dense black in color. A wine or claret colored form was next in abundance. A yellowish brown form was rarely observed. The fourth type was not smooth and polished but minutely pubescent and of considerably less strength than the others. A fifth form was flat and usually closely appressed to the substratum.

All of these hairlike mycelia represent the vegetative part of species of Marasmius. The dead-black shining cylindrical form produced fructifications referable to *M. equicrinis*. The fructifica-

tions of the claret-colored and yellowish brown forms were not observed. The pubescent type was not seen on rubber in a fruiting condition. It was found fruiting on dead leaves and is referred to *M. sarmentosus*.

BROWN SCALY BARK

Sloughing of the outer bark on young trees averaging about 6 inches in diameter was observed in low wet ground on the Rio Ouro Preto. The affected area included about half the diameter of the tree and extended about 2 feet above and below an apparent center of infection. At the upper margin there was a faint indication of a concentric arrangement of the dead bark scales, after the manner depicted and described by Keuchenius. The bark beneath the dead scales was generally healthy, but showed slightly brownish spots which did not produce latex when wounded. The rest of the affected area, which was slightly sunken below the general level and consequently not as thick as the normal bark, produced latex in abundance. The diseased bark, which was much darker than the normal, could be scraped away, leaving a brownish area conspicuous at a considerable distance. No organism was found.

GRAY SCALY BARK

At rare intervals in the vicinity of Para the stems of young trees from 2 to 3 inches in diameter near the surface of the ground bore ash-gray patches of irregular outline. The patches either extended completely around the stem or were in the form of elongated areas on one side.

The general appearance was that of some of the numerous gray incrusting lichens, but when examined the patches were found to consist of a minute fine mycelium, ramifying in all directions around and beneath the small bark scales. There were no indications that this mycelium united to form threads, but under the lens it seemed to follow the fine breaks between the bark scales. The scales in the center of the patches could be lifted with the point of a needle, exposing this mycelium beneath. This apparent loosening of the small bark scales produced an easily perceptible roughening of the surface in the center of the patch and no doubt represented a more advanced development of the fungus, the mycelium at the edge of the patches thinning out until it could no longer be detected. These patches were not found on the branches of Hevea or on the leaves. Similar patches were also found on the smooth bark of young Inga, Cecropia, and cacao and in the same position, viz, about 8 to 10 inches above the ground. In no case did these bark infections seem to have a pathogenic effect on the host. The cortex beneath appeared quite normal, and there was no discoloration. The phenomenon is one of the numerous epiphytic mycelial developments so common on bark surfaces in the Tropics and is of no consequence.

Petch describes a " white stem blight " of Hevea and of tea which is parasitic on the leaves of the latter, and in some instances the cortex beneath the patches on Hevea is found to be brown, having separated from the wood. He describes the fungus as producing an effect as though the branches were whitewashed, due to the loosening of the small bark scales, forming small cords. The Amazon fungus did not produce cords, and the color appearance was gray.

SWELLING OF TWIGS

A fungus (*Cryptosporium* sp.) was found associated with fusiform swellings at the ends of twigs bearing the inflorescence. The relation of this fungus to the swellings has not been determined. The bark at first becomes discolored. Later, longitudinal cracks appear in the bark, exposing the bast, which becomes hard and dry. The inflorescences and leaves of twigs so affected are small and poorly developed.

The fruiting bodies of the fungus may be readily seen with a lens as small black circular flattened pustules with central inconspicuous papillæ.

INDETERMINATE BRANCH CANKERS

On several of the small plantations visited the tips of branches on some of the trees were dead. In the lower part of the Amazon Valley this was usually the result of defoliations by *Dothidella ulei* and its attack upon the stems followed by *Diplodia theobromae*. In some cases the dead twigs showed no signs of infection of any kind, and some appeared in regions where Dothidella was not observed. The bark on such twigs appeared shrunken, with longitudinal cracks through which latex had at some stage of the disease exuded. Small open cankers with the initial stages of callus formations also occurred on branches not yet dead. No organism was found associated with these cankers. They had much the appearance of insect injuries. Similar phenomena have been reported from the East and are considered a result of the attack of *Phytophthora faberi*.

All small dead branches should be removed and burned. The cut should be made sufficiently in advance of the affected parts to prevent further infection. Since the wounds made in cutting off the lesser branches are small and are usually soon healed it may not be necessary to treat them.

Obviously the pruning of small branches can only be practiced during the early life of the tree or during the orchard stage.

The tips of branches may die as a result of the activities of fungi in the roots. In such cases pruning them off is of no avail.

DAMPING-OFF OF SEEDLINGS

In dense patches of seedlings small suppressed plants here and there in the stand, averaging about 6 inches high, were attacked by a fungus directly at the root collar. The tissues appeared brown and shrunken and were overgrown by a white mycelium. A microscopical examination in the field disclosed a sclerotic condition of the mycelium resembling that of some of the soil-inhabiting fungi of the Rhizoctonia or Sclerotium group. The seedlings were yellowing or dead and were held upright by their vigorous uninfected overtopping neighbors. The general effect appeared to be a result of secondary fungous infection following normal suppression. Such a disease is not likely to occur in well lighted and aerated places.

STEM CANKER OF SEEDLINGS

Seedlings 2 to 3 years old were observed showing disease symptoms on the stems just at the surface of the ground. At this point

the stems were conspicuously shrunken for a distance of 1 to 2 centimeters, above which there was a slight enlargement. A zone of brownish mycelia encircled the diseased areas in the region of the enlargement. This when examined was found to be of the nature of an Exobasidium but too immature for determination. The brown strands of a Marasmius were also present.

BLACK-BARK FUNGUS

The species known as the black-bark fungus (*Nummularia anthracodes* (Fr.) Cke.) was first found developing in the living bark on burls caused by *Dendrophthora poeppigii*. It was again found bursting through the smooth living bark above a series of old tapping cuts. The appearance of the fungus in the living bark without any previous indication of its presence is remarkable (Pl. XIII). For this reason its parasitism should be investigated. The subcortical habit between the outer bark layer and the zone of stone cells is characteristic and in this respect differs from the other species of its group found on Hevea. Other related species, such as *Nummularia cincta* and a variety of *N. commixta*, on young smooth trees may first develop beneath the bark epidermis, which is later defoliated, but they are never deep seated and are usually found on dead trunks or branches.

The fungus in all probability is dependent upon wounds to effect an entrance in the bark. Bruises, tapping cuts, openings made in the bark by the sinkers of mistletoes, and insect injuries are apparently the most likely means of entrance. The bark is killed over a considerable area, forming cankers. On the under surface of the bark black lines bordering light-colored areas are formed. These are also found on the surface of the wood. In advanced stages the black lines appear in the wood, which later becomes generally discolored.

The fungus should not be considered of much economic importance and would undoubtedly be absent on trees under proper management. Ridley refers to what is probably the same fungus under the name *Eutypa caulivora*. He states that it is probably a true parasite and comes to the surface to fruit only when the host is dead. He thinks the fungus is saprophytic. Massee considered it certainly parasitic but without proof. Bancroft reports it as a wound parasite.

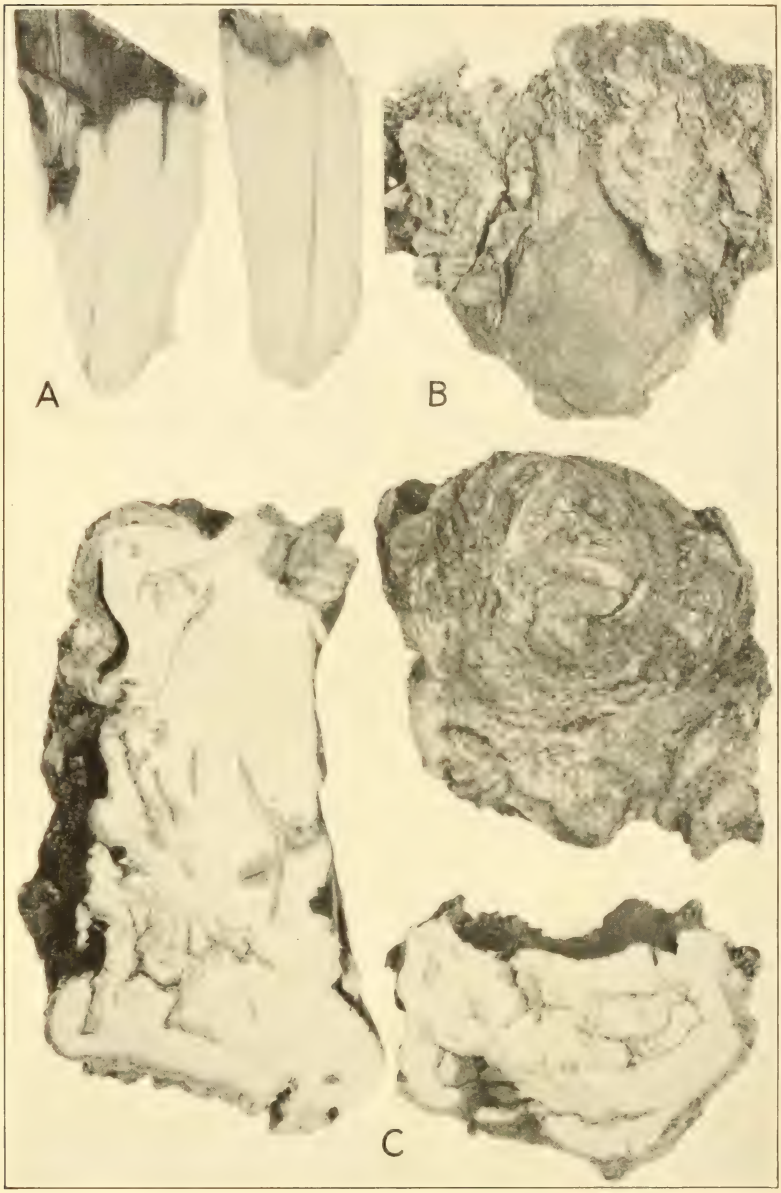
Several other Pyrenomycetes were collected on the dead wood and bark of old tapping cuts. They were apparently saprophytic and may be disregarded here. They will be described in the following paragraphs.

DISEASES OF TAPPING WOUNDS

Various fungous organisms have been observed in and around the tissues affected by the cuts made by the machadinho (a small ax) in collecting the latex. The most common were the die-back fungus (Diplodia), *Dendrographium atrum*, *Stilbum cinnabarinum*, *Nummularia cincta*, *N. commixta* var., *Hypoxylon sclerophlaeum*, *H. bipapillatum*, *Ustulina* and *Xylaria* species, *Eutypa comosa*, indeterminate Thelephoraceæ, and molds.

These organisms, with one or two exceptions, were apparently of little moment as regards the evident production of continuous and

NUMMULARIA ANTHRACODES IN BARK OF HEVEA



DISEASES OF TAPPING WOUNDS ON HEVEA

A, Dark lines in the wood of tapping wounds; B, rubber pad beneath the cortex; C, section through callus nodules, showing irregular condition of the wood. (Nearly natural size)

serious disease. They will be further mentioned in the mycological section near the end of this bulletin.

The most common disease which appeared to be of consequence as a result of the deep wounding of the tree with the ax was usually observed on trees in wet situations. Here the cuts frequently had made little progress in healing the wounds by the production of the usual callus. The removal of the bark around the wound frequently exposed discolored areas either in the form of small or large black patches, becoming confluent with similar neighboring areas or dark strips or streaks extended vertically and parallel to one another on the disorganized surface above and below the cut. These black bands appeared eventually to coalesce laterally, forming the larger diseased areas. These lines extended to a considerable depth in the wood (Pl. XIV, A) and also involved the renewing bark at the lower edge of the cut and that which formed beneath the edge of the old bark above. The cambium of the affected area is destroyed, as well as the viable parts above. The lines in the wood extend for several inches downward and upward from the cut and appear to be caused by infiltration substances from the diseased cambial area. A microscopic examination failed to disclose mycelia of any nature. The color was more intense in the medullary-ray cells. These dark lines were also discovered in the wood of old wounds which had overcome the disease and were completely occluded.

The nature of the cut tends to obscure the presence of the disease. The coagulated latex following the first flow also hides all traces of the disease in early stages and is undoubtedly an effective protection against a rapid spread of the disease. The first sign of the disease which could in most cases be relied upon was the discoloration of the bark and wood at the margin of the coagulated latex. This was apparently followed by a secondary exudation of latex, which when coagulated was of a much darker color than that of the original flow. The greatest area of infection found extended about 6 inches above the cut and 3 inches below. In most cases it was less. The lateral extension of the disease was always less than the vertical. So far as could be determined the infections in most cases had eventually been overcome by the renewing growth. This, however, evidently resulted in a very abnormal healing. It was noted that in wounds showing evidences of the disease having been present the callus was abnormally large and was arranged in vertical ridges. This apparently resulted from the formation of the callus at the sides of the vertically elongated diseased areas. In cases where the disease had continued without healing, the infection had apparently been followed by other wound fungi and insects, resulting in large open cankers (Pl. VII, B).

With the means at hand no organism was found in the diseased tissues. The general character of the disease is similar to that commonly called "black-thread" in the Orient. This disease has been reported in practically all the rubber-growing countries of the East, and is the cause of considerable damage to the renewing bark, resulting in a reduction of yield. The causal organism wherever demonstrated has been found to be a Phytophthora. The identity of the species has not been satisfactorily determined. In Ceylon it has been shown that two species of Phytophthora are found on

Hevea, viz. *P. faberi* and *P. meadii*, but the latter has not been obtained from black-thread. On the other hand, Rutgers in Java has shown by inoculations that black-thread, pod-rot, and claret-colored canker are all caused by *P. faberi*. Other investigators have obtained varying results in different countries. Petch summarizes the evidence as indicating that in the case of Hevea two species of Phytophthora are involved. *P. meadii* causes fruit-rot, leaf-fall, and black-thread, and *P. faberi* causes fruit-rot, leaf-fall, and claret-colored canker. The species found on Hevea in the Amazon Valley will be considered under "Leaf diseases," p. 33.

Tapping cuts recently made at the base of trees growing in damp soil were occasionally observed to exude a slimy or brownish watery excretion somewhat after the manner of the slime flux of oaks in the Temperate Zone. The exuded mass attracted flies and beetles and supported various grayish and greenish molds. Among these were *Aspergillus* and *Penicillium* species. The tissues of the wound became black and sodden but did not appear to spread much beyond the parts actually affected by the ax. The disturbance is probably due to infiltration of spore-laden rain water in the cut, and the effect is local.

A moldy rot of tapped surfaces is recorded from the Malay Peninsula with which a species of Sphaeronema is associated. This disease, however, is reported to spread to the wood, causing shrinkage resulting in large open wounds. A similar disease is recorded from Ceylon, but the organism found in association is *Phytophthora faberi*.

Black moldy rubber excrescences common on tapping cuts are described later.

In connection with the disease of tapping wounds, Akers, in his report on rubber in the Amazon Valley, refers to a "cambium rot which threatens to exercise a most unfavorable influence in connection with the future progress of the rubber industry." He states that the disease appears in a most virulent form when the oriental tapping methods (herringbone system) are employed. He considers this as unfortunate, since this system affords a greater yield of latex with no additional labor, thus substantially reducing the ultimate cost of production. According to Akers the disease occurs on trees tapped with the small ax (machadinho) as well as on trees tapped with the gouge on the herringbone system. With the former method the disease is neither so apparent nor so destructive, because the overhanging flap of cortex covers the incision, and since the coagulated latex in the cut is not usually collected for scrap the wound is protected against atmospheric action.

From experiments carried on in the districts near the Madeira and Purus Rivers and at Manaos in 1913, using different modifications of the herringbone system, the rot appeared on the tapped surface after about 1 inch of the bark had been removed. The tool used was the bent gouge.

The first sign of the disease is the appearance of the mycelium of the fungus in the form of a blue mold on the tapped surface or in the cuts made by the ax. The fungus spreads rapidly over the tapped surface, affecting the thin layer of cortex over the cambium, and later an exudation of a resinous nature appears on the affected

area. The disease was more severe in low-lying localities where the soil is damp and less apparent in well-drained sites. The mortality of the trees was not so much affected as were the quantity and quality of the latex produced. These experiments showed that after a few weeks a healthy bark renewal took place, but healthy action of the cambium and latex cells was seriously retarded by the injuries sustained.

It was reported at Para that the most of the trees tapped by Akers died, and as a consequence the eastern tapping methods fell into disrepute.

It has not been possible to arrive at any definite conclusion as to the identity of the organism Akers found in the tapping wounds. His reference to the mycelium of a fungus appearing as a blue mold on the surface of the cuts may apply either to Diplodia or the bluish gray stage of a Phytophthora. Further investigations in the field will be necessary to determine this point. The fact that a Phytophthora is present on the leaves and fruits of Hevea in the Amazon Valley would indicate that the organism described by Akers may belong to that genus.

Akers also refers to a canker found generally at the junction of the main lateral branches with the trunk and states that "the effect is to rot both branches and stem until the tree becomes exhausted and dies." The opportunity was not afforded to determine the accuracy of this statement or the organism concerned.

LICHENS

The smooth bark of Hevea is frequently covered to a greater or lesser extent with crustaceous or foliose lichens. The former are closely attached to the bark and appear more like green, yellow, red, white, or gray patches of paint than distinct organisms (Pl. I). They are usually inseparable from the bark. The patches may be isolated or run together, forming large areas with lobed or irregular margins. The surface of these patches may be marked with slightly raised undulating tortuose or zigzag lines, small black, yellow, or brown dots, or cup-shaped bodies. The thallus of the foliose lichens is generally raised from and lightly attached to the surface of the bark. It often appears as a rosette with radiating segments and with lobed upturned margins. The colored lines, dots, and cup-shaped bodies are also present on the upper surface of the foliose lichens. They are the fruiting bodies of the fungous element of the thallus.

The lichen crust or thallus is made up of chlorophyllaceous algal cells and the hyphæ of various ascomycetic and basidiomycetic fungi. The algal cells are either regularly distributed or arranged in layers in the mesh of the fungal hyphæ. The result of this combination is to produce a structure closely resembling that of a true fungus. This is especially marked in the case of the hymenolichens. Here the fungous element is a Basidiomycete, and the resulting thallus is reflexed and applanate and resembles a green sessile Polystictus. The lichen fungus in most cases is an Ascomycete. The thallus has a great variety of forms and may be a mere film on the surface of the bark of a much-branched structure resembling moss.

According to the general conception of lichens, the following explanation may be given. It is assumed that the fungous and algal elements live together in mutual cooperation. The latter through assimilation produces organic and inorganic substances from which the former in part obtains nourishment. The fungus in turn supplies certain mineral salts from the substratum and protects the algal plant from drought, which enables it to live on such dry surfaces as the bark of trees. Such cooperation between plants is known as symbiosis and is analogous in part to the relation of mistletoes and their hosts. In the latter, however, the relation, instead of being mutualistic, is only a temporary condition, since the host is finally destroyed.

The lichens are rarely parasitic. They live as epiphytes on the dead bark and derive little or no nourishment from it. Through the secretion of certain acids the outer layers of the epidermis may be destroyed, but the vital tissues beneath are not affected. The excessive development of lichens may cause damage by depriving green surfaces of light and air. Their presence in quantity may in some cases be indicative of the vigor of the tree on which they are found. When the growth of a tree has become so retarded that there is little or no expansion or exfoliation of the bark, lichens develop in great numbers. This condition was observed on Hevea growing in the compact white clay soils of swampy areas. On high well-drained red or yellow soils lichens on Hevea were much less conspicuous. The development of a small black lichen (*Pyrgillus* sp.) on Hevea growing in wet poor soil was frequently conspicuous. It developed at the ground line and extended up the trunk for a distance of 2 or 3 feet. The appearance was that of a black powdery fungus enveloping the roots and lower trunk. The bark over the area was scaly and could be readily scraped off. In very wet situations in dense shade this lichen completely enveloped the trunks of small trees and occasionally extended to the lowest branches. This may have been the organism mentioned by Akers, who states that "the most common form of bark disease is a fungoid growth carrying a black powdery substance on the surface. It appears first near the foot of the tree and gradually spreads up the stem to the main lateral branches." He further states that "for the most part it is found in low-lying localities where the soil is a stiff yellow clay." Although he suggests the remedy of adequate drainage and the application of lime, no information is given as to the identity of the organism.

Some of the most common incrusting lichens on the bark of Hevea are *Phaeographina scalpturata*, *Graphis afzelii*, *Phaeographina* sp., *Trypethelium catervarium*, *Sarcographia labyrinthica*, and *Pyrgillus* sp.

The common foliose species were *Cora pavonia* and *Chiodecton sanguineum*.

The excessive growth of lichens may be prevented by spraying the stems with a copper-sulphate solution. This solution is injurious to leaves and should be confined to the main stem and branches.

The green flat ribbonlike dichotomously branched growths occasionally seen on the bark of Hevea in wet places are liverworts and are related to the mosses. They are epiphytic and are of no consequence.

MOSSES AND FERNS

In wet shaded situations the trunk and branches of Hevea may support quantities of epiphytic mosses and ferns. Only where there is an accumulation of growth of such plants in the forks or in old open cankers caused by unhealed tapping wounds may any damage result. These plants help to hold the moisture in such places and promote the growth of fungi and probably harbor injurious insects.

LEAF DISEASES

SOUTH AMERICAN LEAF-BLIGHT

The leaf-blight caused by *Dothidella ulei* P. Henn. is widely distributed in the Amazon Valley and is apparently coincident with the range of the host in South America. It has not been reported outside of Trinidad and the mainland.

At practically all the stations visited in the lower Amazon region the fungus was found causing more or less damage to planted rubber. The disease was less in evidence in the upper parts of the valley.

The attack on young trees in the lower valley was sometimes very severe. It is without question the most serious leaf disease of Hevea in the American Tropics.

HISTORICAL

Hennings first described the ascigerous stage of the fungus in 1904 under the name of *Dothidella ulei*. This material was collected by Ule in August, 1900, on the Jurua, in August, 1901, at Jurua Miry in Acre Territory, and in July, 1902, at Iquitos in Peru, on the Amazon, the last collection being considered the type. Attention was called to the fungus as a possible important parasite. From the same material Hennings described the pycnidial stage as *Aposphaeria ulei*. However, the early investigators from insufficient field observations did not regard the fungus as a serious parasite. When it was first observed in British and Dutch Guiana in 1907 it was not regarded as capable of causing much damage.

Drost reported on a disease of nursery plants at Paramaribo in Dutch Guiana in 1910 which was undoubtedly the disease in question. Both a pycnidial and a Ramularialike conidial stage were observed. Although he called attention to the effect of the disease on leaves, stems, and twigs, he did not regard it as serious.

In 1911 Kuyper described the disease in Dutch Guiana with considerable detail under the name of *Fusicladium macrosporum* and observed that nursery plants were frequently seriously attacked, but that the injury to mature trees was negligible. He figured and described a pycnidial stage, but failed in infection experiments to demonstrate a higher fructification. In 1912 Kuyper again reported on the disease from Dutch Guiana, but did not regard it as especially dangerous, although trees of low vigor died when attacked. Griffon and Maublanc in 1913 studied the organism on material collected in 1912 by V. Cayla on cultivated Hevea at Para (Belem). They considered the conidial or Fusicladium stage and

the pycnidial or Aposphaeria stage found on the same leaves as the ascigerous or Dothidella stage to be stages of the same fungus and regarded it as of little importance and serious only on nursery plants.

In June of the same year V. Cayla suggested the identity of the disease described from Para by Griffon and Maublanc with that collected in the upper Amazon by Ule and with that described by Kuyper from Dutch Guiana. Bancroft reported the disease from British Guiana in 1913 and considered it of importance on nursery plants only. He sent material (conidial) to Kew, where it was described as new under the name of *Passalora hereae* Massee. In 1914 Petch suggested the relationship of the pycnidial and conidial stages described by Kuyper, Griffon, and Maublanc with *Dothidella ulei* and the probable importance of a disease which can attack both old and young trees. He further commented on the identity of the organism and its importance in 1915. In a series of studies from 1915 to 1917 Stahel demonstrated the identity of the organism described from the various regions. On the basis of its relations with and differences from the saprophytic genus Melanopsamma he renamed the fungus *Melanopsammopsis hereae* (1915). He reported that the attacked leaves were destroyed, resulting in the death of the tips of the branches. A treatment for the disease was given by Stahel in 1916. Rorer reported on the disease in Trinidad in the same year, stating that the fungus must have been present in that island for a number of years but only became epidemic during July, August, and September, owing to certain favorable weather conditions at that time of the year. He further stated that owing to its importance in Dutch and British Guiana the disease must now be considered the most serious trouble of Hevea in the American Tropics.

In 1916 Bancroft published additional observations on the disease in British Guiana. He called attention to the probable source of the inoculum from *Hevea confusa* and one other undetermined species in the forest and the wide spread of the disease in the colony. He found it less common on the coast, but prevalent in areas of large plantations.

Bancroft again gave an account of the disease in Dutch and British Guiana in the following year. He stated that the disease was so widespread and existed in such virulent form as to lead to the assumption that unless some means was found for its control the cultivation of Hevea in Dutch Guiana would soon prove unremunerative. The most complete account of the causal organism with methods of control is that published by Stahel in 1917 under the name *Melanopsammopsis ulei*. Rands in his report of this year emphasizes the importance of the disease and the necessity for its control.

HOSTS

The fungus apparently attacks all species of Hevea. Owing to the fact that *Hevea brasiliensis* predominates over all other species the fungus is naturally conspicuous on that host. Through the kindness of the director of the Botanic Museum at Para all the Hevea specimens in the herbarium were examined. The fungus was found on specimens labeled as follows: *Hevea brasiliensis*, *H.*

randiana Hub. (Para), *H. spruceana* Hub. (Obidos), and *H. collina* Hub. (Parintins). It is to be remarked that all of these collections are from the lower Amazon. The fungus also was found sparingly on trees in the Botanical Garden at Para labeled as follows: "*H. brasiliensis*, *H. collina*, and *H. spruceana*." On the label of the type specimen of Dothidella at Para the host is recorded as *H. patudosa* Ule.

The fungus is reported on *Hevea confusa* in British Guiana and on *H. guyanensis* in Dutch Guiana, and it was found sparingly on *H. guyanensis* at Manaos. It seems that the type of the leaf of this host may be more resistant than the more delicate leaf of *H. brasiliensis*. The fungus is an obligate parasite and is highly specialized on Hevea. No other host is known. As is the case with most true parasites it will not grow on artificial media.

LIFE HISTORY OF THE FUNGUS

The life history of the fungus includes three distinct spore forms. They are, in order of production, conidia, pycnidia, and ascospores.

The fungus first makes its appearance on the young leaves as they unfold from the bud, or two or three days afterwards, or at any time before the leaf reaches maturity. The severity of the infection, however, becomes less with the increase in age. Translucent spots, which soon become olive or blackish green, appear on the young leaves. These spots are usually at first scattered either along the edges or promiscuously over the entire surface but may soon coalesce, until the entire leaf surface is involved. The edges then begin to roll, and the entire leaf crumples up, becomes black, and hangs limp from the twigs as though recently scorched by fire (Pl. XV, A).

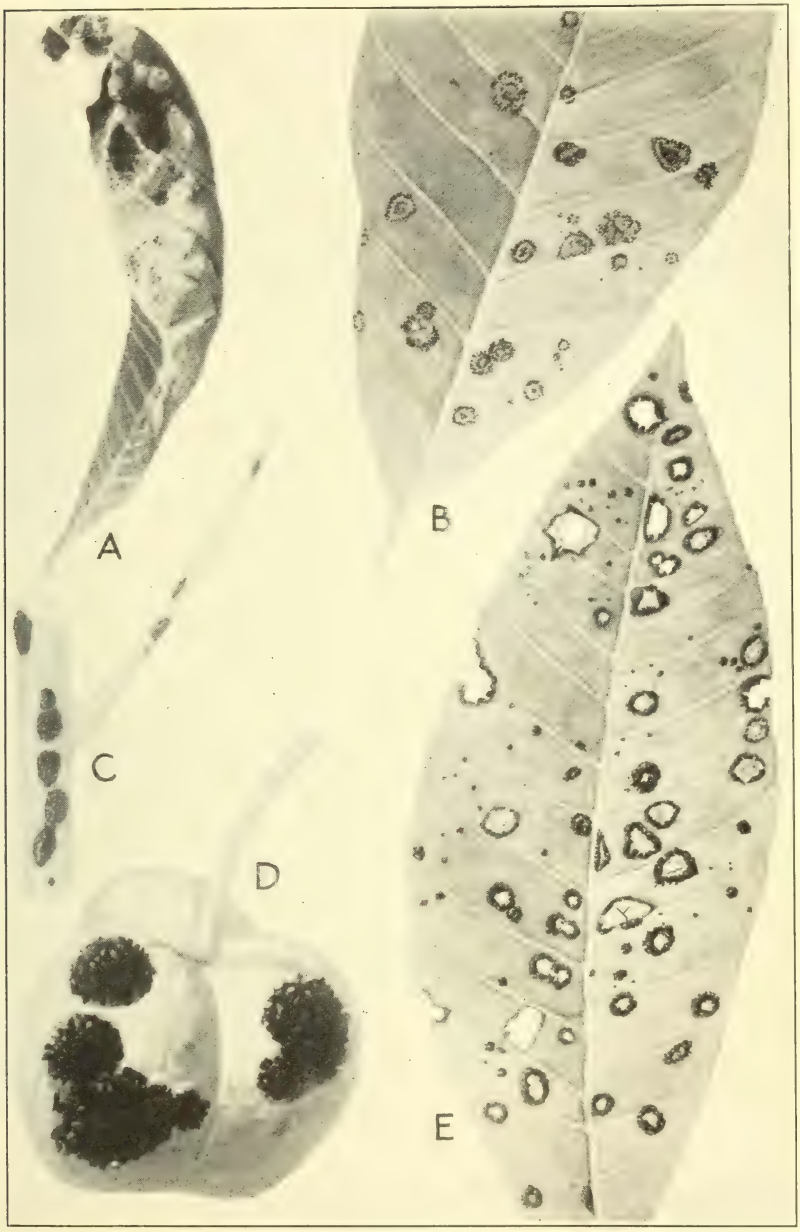
At other times only a portion of the leaf at the edges or at the tip or in the region of the glands at the base is infected. The unequal stress caused by the continued development of the uninfected parts tears and splits the infected portion, so that it may fall away or leave irregular holes extending toward the midrib. The leaf then may present a very ragged appearance, rolling inward from the edges and upward from the tip, so that the leaves on a twig may be bunched or snarled. Finally the leaflets fall, usually leaving the petioles attached. When the infections occur sparingly on the leaf and do not coalesce, owing to the rapid development of the leaf, the infected tissues become discolored and fall out, with the resulting shot-hole effect. It is evident, that the conidial stage of the fungus is dependent upon the early developmental stages of the leaf tissues; otherwise leaves four or five days old when first infected would be entirely involved. The following uncontrolled experiment further illustrates this point. A quantity of conidia-bearing leaves taken from a plantation at Para was carried during a period of heavy rain into the near-by jungles and laid over the leaves of a young wild tree 3 feet high bearing leaves in different stages of development. The very youngest leaves showed infection in three days' time. The older leaves remained free from the disease. The rapidity with which young unfolding leaves during rainy weather may be infected is surprising. Leaves observed to be unfolding, hanging vertically with their edges adhering, due to the excessive atmospheric moisture,

and showing no sign of infection would be green or olive-green spotted on the fourth day following.

The appearance of the green or olive-green velvety coating on the infected spots is due to the development of an immense number of conidiophores, minute erect stocks with swollen bases bearing the 1-celled or 2-celled conidia. These may appear on both sides of the leaf but usually in greater number on the under side. They may develop directly through the epidermis or appear one or more together through the stomatal openings and in greater numbers at the margins of the infected areas. The mycelium may extend superficially beyond the immediate point of infection from which conidiophores develop. A section through the infected tissues shows that the mycelium is intercellular, with palmate or branched haustoria invading the cells. On emerging the mycelia become light or dark brown, conspicuously septate, and may entirely obscure the surface of the leaf. The conidia are of varying shapes, but when fully mature are generally oblong-elliptic. They are produced in great numbers and are believed to be chiefly instrumental in propagating the fungus. Since new and old leaves are generally present, either on the same or different individuals, continuous propagation by the wind-borne spores is made possible. The spores germinate immediately, forming an expanded disk, from which a germ tube is developed, which rapidly penetrates the young leaves and again produces conidia. In damp, rainy weather they may be the cause of a rapid spread of the disease, and young trees may become entirely defoliated. The second crop of leaves is infected, and the process goes on until the twigs and branches are depleted of food material and either die or fall a prey to Diplodia, which finally causes the destruction of the tree. Stahel reports that three successive defoliations in a period of six months caused the dying back of the crown of trees 5 to 6 years old. In the case of older trees defoliation of branches resulted in loss of vigor and reduction of latex.

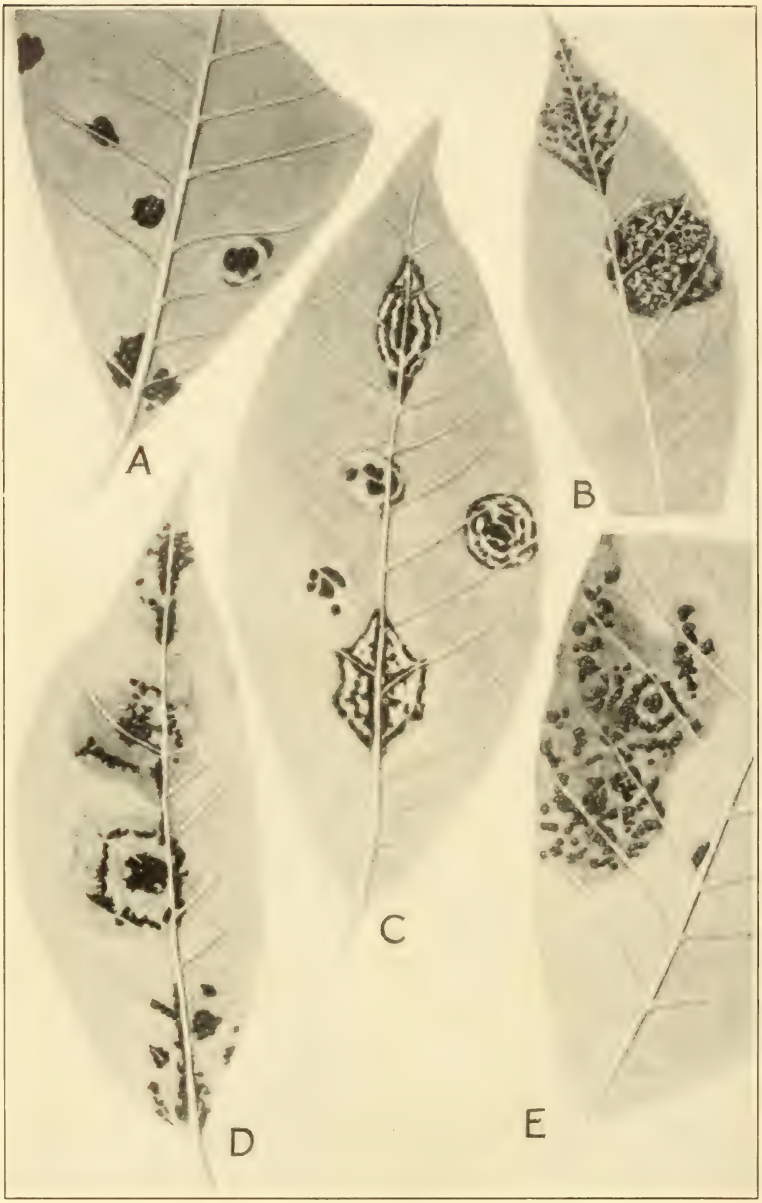
If the young leaves, owing to their rapid growth, are not entirely parasitized or spot infections on more mature leaves have not increased in size from the same cause, small spherical black bodies appear around the edges of the original areas of infection. These are the pycnidia, representing the second stage of development (Pl. XV, B). The pycnidia which develop from brown septate mycelia may appear singly or may become united in masses on a pseudoparenchymatous stroma, completely incrusting the edges of the spots. They are very rarely developed on the under side of the leaf. The pycnospores are developed on short stocks arising from a hyaline inner layer contrasting with the dark stromalike walls of the pycnidium. The spores are very small and are germinated with difficulty. They probably take little or no part in the propagation of the fungus.

From one to two months after the appearance of the second or pycnidial stage larger black spherical bodies appear around the margin of the old spots, or they may be grouped in the center of small brownish hypertrophied areas scattered over the surface of the leaf. This is the third or perithecial stage and represents the last and highest development of the fungus, the production of ascospores (Pl. XV, E). The perithecia are either grouped in stromatic masses or



LIFE HISTORY OF DOTHIDELLA ULEI ON HEVEA

A, Fusicladium stage on a young leaf; B, pycnidial stage; C, infections on stem and petiole; D, infection of fruit; E, perithecial stage



BLACK-CRUST ON LEAVES OF HEVEA

Various appearances of *Catacauma huberi* on young and old leaves

appear singly or in clusters of three or four and may be on either side of the leaf. Pycnidia and perithecia may occur together on the same spot, or pycnidial cavities may be contained in the same stromata with the perithecia. This is a rare condition, however, and when pycnidia are present they may be distinguished in a section of the stroma by their size and shape. Evidence of the occurrence of conidia was found by Stahel on the original material studied by Hennings. The old leaves may sometimes be very heavily infected, and when in this condition they are very rough when drawn through the hand. The ascospore stage was common in the Amazon Valley and was the only stage found in some localities where the trees were of a uniform size with little variation in the age class of the leaves. The production of the ascospores is evidently continuous at all seasons of the year and probably plays a greater rôle in the propagation of the fungus than has heretofore been believed. The spores are capable of germination immediately after their expulsion from the ascus. They may be carried by the wind, rain, or insects to the young leaves and give rise to the first or conidial stage.

Stahel's experiments with ascospores showed that they did not withstand drying for more than 4 to 6 hours. They germinated in water in about 2 hours. He sowed the spores on young leaves in a damp chamber and found it required about 16 hours for the germ tube to penetrate the leaf partially. It appears that the disease has not been experimentally reproduced by means of ascospores sown on young leaves under normal conditions. One infection resulting in the production of conidia was obtained at Para by inoculating with ascospores young folded leaves which had been protected from spurious infection with transparent oiled-paper bags. Four different buds were inoculated and again inclosed in the bags. Infection occurred at the end of one week. This result is far from conclusive and is open to many objections, but there was no opportunity for more critical work. All the evidence heretofore presented on the relationship of the different stages appears to be based on anatomical studies by tracing the mycelial connections in the leaf. It is highly desirable to establish the life history of the organism by extended and critically controlled experiments under natural conditions.

All three spore forms occur on leaves, petioles, young stems, inflorescence, and fruits (Pl. XV, A to E). On the petioles and stems the infections are at first noticeable as slightly elevated greenish or yellowish areas. These soon become black, the surface tissues crack open, the bast is hypertrophied, and definite, though small, cankers are formed. Cankered stems bearing perithecia and terminating in well-developed young leaf clusters were frequently observed. The longevity of the mycelium in the stems has apparently not been demonstrated. Cankers on 3-year-old stems were found to have abundant fertile perithecia. Cankers were found on older stems, but the perithecial stroma had deteriorated and no ascospores were found. In case the branch survives the infections it is not likely that a viable mycelium capable of producing perithecia survives after three years. Infection of inflorescences soon resulted in a shriveling and curling of the smaller parts and the falling of the flowers.

Young vigorously developing fruits in the neighborhood of Para were found infected. The necrosis is very striking. Small elevations

first appear on the surface of the pods. These soon become black specked with pycnidia and may be elevated a millimeter or more above the surface of the pod. Later, the surface of the elevations becomes roughened. With the development of perithecia cracks appear, and finally the entire canker breaks up through the invasion of secondary fungi. Chief among the latter are *Diplodia theobromae* and *Gloeosporium alborubrum*. The entire thickness of the outer pod tissues is involved. When one or more of these cankers develop on a pod it soon dries up, remains suspended for a time on the tree, and then may either fall from its stem, which remains attached to the tree, or the stem may fall with the pod. The immature seeds are rapidly attacked by Diplodia, and their contents soon become black and shrunken. A count of the pods on some trees near Para showed an infection of more than 60 per cent.

CONTROL

The methods that have been proposed for the control of the disease have not been carried out to the extent that would be necessary for definite conclusions. Since individuals in a large plantation may not be treated with profit, a more comprehensive control should be evolved.

PROTECTION

To afford protection by giving attention to the normal environment certain measures would be considered. To interfere with disseminating agents would probably involve a consideration of prevailing winds. It is not known to what extent insects and other animal life distribute the spores of the fungus. Local animal life is probably a factor. Spores have been detected on the bodies of ants, slugs, and bees. In establishing new estates in regions far removed from infected plantations or extensive stands of wild trees a knowledge of the prevailing direction of winds would no doubt be of service. The selection of the site with regard to altitude and also intervening elevations giving direction to air currents would be considered. Since the rapid propagation of the fungus is promoted by rain, fog, and dew, the selection of the higher sites where the wind would be a factor in dispelling the moisture on the leaves should be considered. Heavy dews during the dry season would no doubt prove as effective in promoting the development of the fungus on young closely adhering leaves as rain during the wet season. Rapid evaporation caused by wind on exposed sites would tend to reduce the severity of infection. Stahel has pointed out that the spread and destructiveness of the fungus are largely dependent on climatic factors. He found that trees on exposed places in the full sweep of the wind were less severely infected. Consideration of soil reactions with regard to fertility is of importance in that the more vigorous the tree is the less liable it is to be rapidly weakened by repeated defoliations and hence to attack by secondary parasites. It has been observed that the effect of the fungus on trees growing on soils of low fertility is more serious, owing to the rapidly weakened branches being attacked by Diplodia and other fungi. Wet, poorly drained soils promote the rapid action of the fungus for the same reason, viz, that the trees are usually less vigorous through

insufficient aeration and frequent decay in the roots and the favorable moisture factor in relation to spore production and germination. A noticeable case in point was the destructive effect of the fungus on several small trees growing in swampy soil as contrasted with the vigorous appearance of near-by trees growing on dry soil. The latter were also infected but had no dead branches. The leaves of the former were in all stages of infection and had many dead branches, with secondary fungi.

The application of inhibiting substances by spraying or dusting would be difficult in the case of tall trees and large areas unless the use of an airplane was feasible. On nursery stock and young trees the disease may be controlled by spraying with Bordeaux mixture, as has been shown by Bancroft and Stahel.

EXCLUSION

Exclusion of the disease from regions of the most northern optimum range of Hevea by establishing plantations from seed or cuttings which, so far as known, do not carry the fungus and the enforcement of strict quarantine regulations are worthy of consideration. Seeds and cuttings brought from regions where the fungus is known to occur should be treated. Care should be taken to avoid the use of twigs showing old cankers. Trees growing in Florida, Haiti, and Cuba have not yet shown signs of attack. The disease, however, would no doubt follow its host into any region unless rigid quarantine measures were taken against its introduction. The conditions that prevail in Trinidad imply that the fungus may become of less importance the farther north the cultivation of Hevea is extended.

ERADICATION

Forestal and crop associates are to be considered, in that under the former is included the infected wild rubber in the vicinity of the estate. It has been pointed out by Bancroft that any attempt to eliminate wild rubber in the region of estates is impracticable both on account of the cost and the probable great distances from which spores may be carried by the wind. Local eradication of wild Hevea, however, would go a long way in reducing the amount of spore production in the vicinity of the plantation. Crop associates in many cases carry the ubiquitous Diplodia, promote the moisture content of the soil and air, and protect the fallen infected leaves from drying.

The cutting out of all new shoots in order to reduce conidial infection on young leaves over a period of several weeks, as proposed by Stahel, is scarcely feasible over large estates. The fact that the leaves are frequently in all stages of development throughout the year makes such a procedure difficult.

The elimination of infected leaves from estates would almost necessarily be a continuous process, owing to the irregularity of their development and the continuous production of spores from the wild trees. However, repeated cleaning of the estate, if it could be cheaply and efficiently done, would gradually reduce the spore production and lessen the degree of infection.

Any plan of direct eradication would require the cooperation of neighboring estates and a consideration of cost.

IMMUNIZATION

Very rarely individual trees standing among infected groves are entirely free from the disease. Whether such trees have developed immunity or are uninfected through accident of spore distribution it is impossible to state. Harrison calls attention to the fact that in every plantation healthy trees are observed. However, individuals showing resistance and other desirable qualities could be selected for experimental work on the chance that immunization may come from certain individual peculiarities and can be stabilized.

Since the trees may be propagated by means of cuttings and grafts, results could be obtained in a comparatively short time. Bancroft in explaining the ravages of the fungus in plantations has suggested that Hevea of an especially susceptible type may have been selected in the beginning. It is interesting to recall that practically all plantations were started from stock obtained in the lower Amazon Valley, where the ravages of the disease were observed to be most severe. Likewise, the seeds originally taken from Brazil by Wickham may have been chiefly from the white variety (branca) of Hevea, which, so far as observations have been carried, appears to be very susceptible to the disease.

It is not known whether Hevea will cross with other related rubber-producing trees. The latter are not attacked by the disease.

Rorer is of the opinion that the only hope of combating the disease is through the development of resistant types. Rands, in his work on brown bast, has demonstrated the practicability of creating resistant strains. It appears, however, that much may be learned by thoroughly investigating the influence of environmental factors on the development of the fungus.

THE DISEASE IN THE FOREST

Although the disease as shown is widely distributed in the Amazon drainage, it is only in the lower stretches of the valley that the disease was observed to be very destructive. At many of the points visited along the Madeira River and at points farther on in Matto Grosso, trees of any age class and with leaves in all stages of development on terra firma were either free from the disease or but slightly influenced by it. Very few infections were observed at Manaos.

On the Rio Beni in Bolivia the disease was scarcely noticeable at the several stations visited. The magnificent size and quality of the trees in the upper Amazon drainage on terra firma would seem to imply that the disease has had but little influence on their development.

It is the writer's opinion that when a thorough survey has been made of the available territory, regions will be found where Hevea may be grown without much danger of the profits being reduced by the action of this disease. There is no reason to believe that Hevea undergoes a change making it more susceptible to the disease when grown under plantation conditions. It should be remembered

that when a species is established in pure stands the conditions for the propagation of a parasitic fungus to which the species is susceptible are greatly intensified. This is fundamental and is a condition long recognized in forestry practice. In the wild state nothing like the degree of infection observed in plantations is encountered. This is attested by the fact that in the jungle all trees, though they may have had the disease at different stages of their development, reach maturity without being seriously damaged. The natural jungle growth is a factor in this connection and serves as a screen against the wide distribution of spores locally and otherwise. These and other conditions pertaining to the natural habitat lead to the consideration of a possible plan whereby a natural stand of Hevea, if sufficiently great per acre, may be augmented by spot plantings and the area managed under improved estrada conditions. Owing to the influence of the natural jungle growth on air currents and the distribution of spores a state of equilibrium would be maintained.

BLACK CRUST OF LEAVES

The fungus causing the black crust of leaves (*Catacauma huberi* (P. Henn.) Theiss and Syd.) is very widely distributed in the Amazon Valley, having been collected from Para to the highlands of Bolivia and Peru. It occurs in Dutch and British Guiana and in Trinidad. This fungus has not been considered of economic importance. Recently at several localities, notably at Tres Casas, Santa Laura, Democracia, Porto Velho on the Rio Madeira, at Cocal Grande near Obidos on the Amazon, and on the Rio Ouro Preto in Matto Grosso, it was found defoliating young seedlings. It was also very common at Itu in the Acre Territory and at Cobija and Porvenir in Bolivia. The immature leaves were rapidly parasitized and killed before the fungus could reach maturity. This resulted in reduced vigor, with subsequent attack at the tops by secondary fungi. The fungus is very common on mature leaves of young stump shoots and of full-grown trees, especially in the denser parts of the jungle or when suppressed by a dense canopy of leaves and vines. The fungus is less common on Hevea planted in the open or on trees whose crowns project above the surrounding jungle growth. On several small plantations without intercrops the fungus was absent. From these observations it appears that the fungus would not be expected to be of importance on plantation rubber.

Catacauma huberi, both in its early stromatic condition and later, is very conspicuous and easily recognized (Pl. XVI). Shining black incrustations appear on the under side of the leaves, with corresponding yellowish spots on the upper side. The crusts are arranged in circles, sometimes separated by greenish zones, and inclosing a central stroma, or radiating outward from a common center along the veins form a network. Not infrequently the crusts are uniform in shape, without ramifications; and, in this state on casual notice, they may be mistaken for *Dothidella ulei*, with which this fungus is often associated.

Even on old leaves the crusts are sometimes so abundant as to cause them to fall prematurely. In such cases the entire leaf be-

comes yellow. In ordinary infections only the tissues immediately beneath the crust or in the near vicinity are affected.

The globular perithecia are embedded in the crust with their mouths slightly raised above its surface and are rather widely spaced. Around the margin of the perithecial stroma a secondary stroma is present, which apparently represents the conidial stage of the fungus.

The species is one of the most conspicuous leaf diseases of Hevea in the Amazon Valley. It is not likely to be of much importance except on nursery plants.

GLOEOSPORIUM LEAF-BLIGHT

In the case of a number of leaf-spot diseases it has not been possible to arrive at any definite conclusion as to the causal organism. Since species of Gloeosporium were the predominating fungi they have been grouped under the above head. Two types of infection prevail.

SHOT-HOLE

When the affected tissues of a leaf occupy but a small area and fall out in the last stages of the disease, leaving holes, the effect is spoken of as shot-hole. Such spots with which Gloeosporium is associated are common on the leaves of Hevea.

On leaves of intermediate development on young seedlings, small translucent spots from 2 to 3 millimeters in diameter with a purplish brown border surrounded by a lighter colored zone are common (Pl. XVII, B). The appearance is the same on the lower side of the leaf. Before the affected tissues fall out the fungus appears in the center of the spots on both sides of the leaf as faint pinkish white pustules. These pustules are made up of numerous hyaline 1-celled spores somewhat constricted in the middle or budding at the ends and are borne on short stalks. The fungus is temporarily referred to *Gloeosporium alborubrum*. This is the first fungus to appear and may well be considered the causal organism. It is followed by *Phyllosticta heveae* and this in turn by *Pestalozzia palmarum* and *Cladosporium herbarum*. The last is present on both the old and young leaves and is probably the same fungus described by Vincens on nursery plants at Para. He described a Scolecotrichum as the principal causal agent, which he named as a new species, *Scolecotrichum heveae*.

A small uniformly light-brown circular spot averaging 2 millimeters in diameter, frequently found in dense shade on leaves of seedlings younger than the preceding, was apparently caused by a scale insect, although this could not be definitely determined. Occasionally an insect could be distinguished resting directly in the center of the spot. Most of the spots, however, gave no evidence of the presence of the scale. The light-brown to pinkish spore masses of the fungus could sometimes be distinguished in the center of the spots when fresh, but they were faded when dry. The fungus is *Gloeosporium alborubrum*.

This spot was common in several localities and was the cause of an early leaf fall. The diseased tissues fall out in the last stage

with the usual shot-hole effect (Pl. XVII, B). The leaves were sometimes so excessively perforated that little of the uninfected tissues remained.

Fusarium heveae and immature stages of *Diplodia theobromae* followed on these spots when old.

The forms of infection involving a part of the entire leaf surface were of less frequent occurrence, but were usually more destructive.

WHITE OR GRAY LEAF-SPOT

On mature leaves grayish or whitish areas extending back from the tips or edges but rarely completely surrounding the leaf or scattered over the surface as irregular spots and in all cases larger than shot-hole were of common occurrence. The infected tissues usually remained intact and did not fall away to form holes. A Gloeosporium forming brown spore masses was always found associated with this disease. The organism is referred to *Gloeosporium heveae*. The diseased tissues became white and bleached when old. Diplodia then either appeared on these areas while on the tree or after the leaves had fallen.

RIM-SPOT

Another form of leaf-spot with which Gloeosporium was associated was that of pale-brown or yellowish spots in a zone near the edge of nearly mature leaves. These spots may later coalesce to form a brown margin for a part of the distance around the leaf. The discolored area, however, is of a lighter color than that in rim-blight. The tissues remained their original color and did not bleach out or fall from the leaf. Brown spore masses appear in the center of the spots, which agree with *Gloeosporium heveae*. The disease was observed at two different stations on young trees about 5 feet high and did not appear to be of much importance.

BLIGHT OF YOUNG LEAVES

The most important leaf disease for which Gloeosporium apparently is solely responsible took the form of a complete infection of the entire surface of young leaves. Appearing first as irregular watery spots along the margin or at the tips, the areas soon spread to the petioles and infected and killed the tips of the branches. The leaves soon became uniformly infected and turned greenish black, resembling the conidial infection of *Dothidella ulei*. The fructifications of the fungus appeared on the lower side of the leaf along the veins or midrib, at first as slightly grayish patches, becoming pinkish and fading when dry. The fungus may be referred to *Gloeosporium alborubrum*.

The disease was first observed in a patch of young seedlings growing in wet soil and had the appearance of a serious parasite. Some 20 or 30 plants had succumbed to the disease. This result, however, may have been intensified by unfavorable growth conditions and would not occur in plants of high vigor.

It would appear that the type of infection is influenced by the age of the leaf.

REDDISH BROWN OR PURPLE LEAF-SPOTS

A common leaf-spot (*Phyllosticta* sp.) on mature leaves appears during the latter part of the dry season. Small reddish spots develop over the surface of the leaf or at the margins. The diseased area extends inward along the veins, or large areas are affected which do not involve the margin. The spots increase irregularly in size and may involve large areas of the leaf surface. The spots assume a deep reddish brown or reddish purple (Pl. XVIII, C). In late stages the epidermis may become separated. It turns ash gray and may be peeled from the tissues beneath. The immediate margin of the spot is purplish brown, frequently fading to lighter shades for a considerable area around the spot. The affected tissues in the central part of the spots sometimes fall away, leaving an irregular hole in the leaf. The color on the lower side of the leaf is usually a uniform reddish brown. The normal functions of the leaves are considerably affected, and the result may be a premature defoliation.

The fungus most commonly associated with this leaf-spot is a species of Phyllosticta which differs in several details from the species previously described. *Pestalozzia palmarum* and *Diplodia theobromae* occasionally are found on the spots after the fall of the leaves.

A disease of more or less common occurrence on mature leaves of Hevea takes the form of small or large irregular reddish brown spots which frequently involve the margins of the leaves. The fungus associated with this disease is a Phyllostictina which appears to be different from species in this group previously described.

BROWN LEAF-BLIGHT

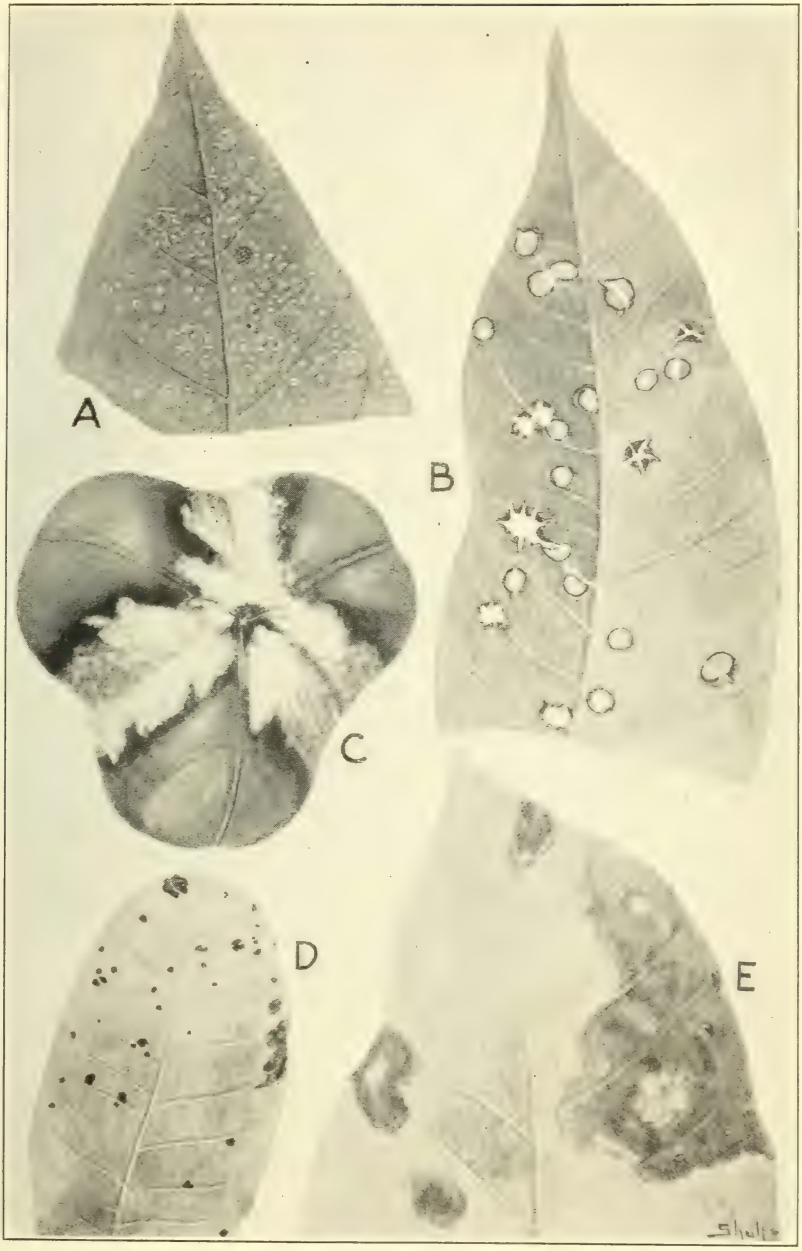
A disease known as brown leaf-blight (*Phyllosticta heveae* Zimm.), which starts at the tips and extends uniformly over the leaf in half or more of its length, is more or less common on young trees in dense shade. The affected area at first is a light yellowish brown or buff on both sides of the leaf. The color deepens with the advance of the infection, and in final stages it is dark brown (Pl. XVIII, D). *Phyllosticta heveae* is associated with the disease to the exclusion of all other fungi. After the leaves fall or after their death on the tree *Diplodia theobromae* may appear.

This disease has also been found on Hevea in Florida.

GRAY LEAF-BLIGHT

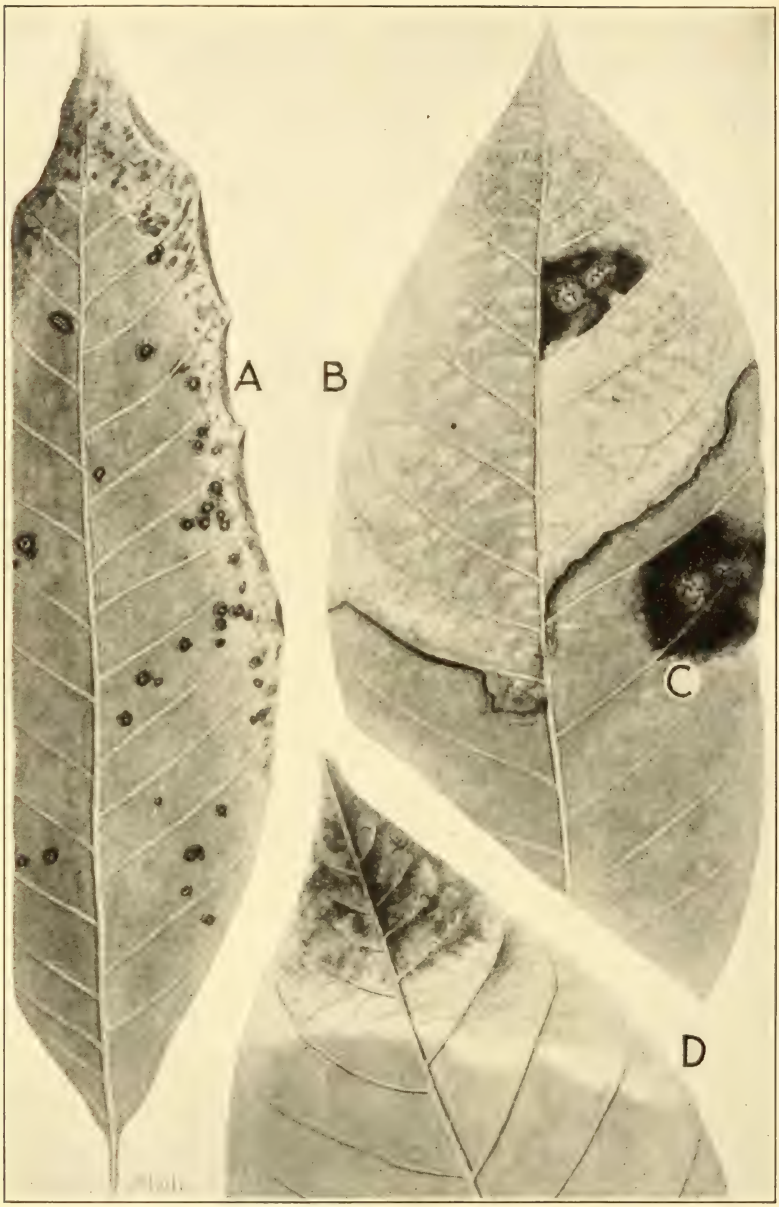
A number of leaf diseases (*Leptosphaeria* sp.; *Coniothyrium* sp.) are confined to rather limited areas of the leaf surface and cause injury by multiplication of the spots, which may become confluent, thus eventually affecting large areas. Two leaf diseases more or less common on Hevea usually start at the tip of the leaves and gradually progress uniformly toward the petioles. Only a small portion of the green surface of the leaves at the base remains, or the disease may extend only half the length of the leaves.

A species of Coniothyrium is associated with one of these diseases. The upper side of the diseased surface is whitish gray and



LEAF DISEASES AND POD-ROT OF HEVEA

A, *Cephaleuros virescens* on leaf; B, leaf attacked by Gloeosporium; C, Phytophthora pod-rot; D, *Cephaleuros parasitica* on a leaf; E, leaf attacked by *Ascochyta* sp.



LEAF DISEASES OF HEVEA

A, Rim-blight on leaves; B, leaf attacked by Coniothyrium; C, reddish brown or purple leaf-spot with which *Phyllosticta* sp. is associated; D, leaf attacked by *P. heveae*

is separated from the uninfected parts by a purple zone. The under surface is reddish brown (Pl. XVIII, B).

In the other a Leptosphaeria is apparently the causal organism. The upper side of the diseased surface is whitish gray with a faint purple tinge and is bounded by a brownish zone. The epidermis in late stages is separable from the tissues beneath. The under surface of the leaf is whitish gray.

Diplodia theobromae is present on the leaves in both cases.

Not infrequently leaves of middle age on young trees growing along the river banks were affected with a blight similar to that with which Ascochyta was associated. The fungus, however, in this instance was exclusively *Pestalozzia palmarum* Cooke. The leaves begin to die at the tips, and the spot spreads uniformly toward the base until about midway it affects only the margin for the remainder of the distance. The dead parts of the leaf assume a whitish gray appearance above, with small greenish spots scattered over the surface. The lower surface is a uniform reddish brown. The edges of the leaves do not curl, as is the case in rim-blight.

CLADOSPORIUM WILT

A greenish black mold is sometimes found on withered leaves of young Hevea in damp situations. *Cladosporium herbarum* is associated with this wilt, and in the absence of other fungi it may be the contributory cause of the disease. The mold consists of a superficial greenish brown mycelium, springing from small cell masses beneath the epidermis in the form of erect bundles. The conidia are produced terminally or laterally on these erect conidiophores, singly or in chains. The unicellular conidia are from 1 to 3 septate, depending upon the age of the part of the conidiophore from which they are produced. The conidia resulting from a division of the basal or lateral cells of the conidiophore are usually 1 septate. Those produced terminally are unicellular. The conidia are variable in shape, globose to elongate, hyaline to brown, depending upon age, and they are thickened at the ends.

The fungus on Hevea is probably not of importance and is indicative of a weakened condition of the host.

ASCOCHYTA LEAF-SPOT

This leaf-spot fungus (*Ascochyta* sp.) attacks the leaves at the time they reach maturity. Blackish green or mouse-gray spots appear promiscuously over the upper surface of the leaves, which may later become united, affecting large areas of the surface. The spots are reddish brown below. They become gray in the centers and, being surrounded by the greenish or grayish discoloration, are rather conspicuous after the uninfected parts of the leaf turn brown (Pl. XVII, E).

In the mesophyll of the leaf the hyphæ of the fungus are found and congregate beneath the epidermis to form numerous small pycnidia in the gray parts of the spots. The pycnidia are small, somewhat flattened, and submerged in the tissues. When mature they open with a small round-beaked ostiole. The spores are hya-

line, usually obtuse at the ends, and 1 septate. In a swollen condition they may be constricted at the septa.

The disease appears to be new, but was not common and is probably of little consequence at present. Young trees in dense shade were defoliated and twigs were attacked. The fungus is also found on old leaves.

PHYTOPHTHORA LEAF-BLIGHT

In a small plantation near Para where the trees were associated with secondary jungle growth a gray leaf-spot (*Phytophthora faberi* Maubl.) was found both on recently fallen leaves and on leaves still attached to the tree. After several heavy rains the leaves fell in greater numbers and the green pods began to show infection. On this estate and in the jungle near the waterworks at Utinga similarly infected leaves were found. These leaves were variously mottled with yellow and purple, particularly along the midrib, where the grayish spots were most in evidence. The leafstalks showed shrunken discolored spots and fell with the leaves. An examination of the gray splotched areas showed the characteristic fructification of a Phytophthora. The fungus in all essentials is apparently the same as that attacking the pods and will be discussed under that head (p. 51).

PARODIELLA MELIOLOIDES

A fungous disease was reported in 1904 by Hennings on living leaves of Hevea from material collected by Ule at Jurua Miry in August, 1901. The causal species (*Parodiella melioloides* (B. and C.) Wint.) was reported to be especially associated with Euphorbiaceæ in Brazil and was also found on the leaves of *Manihot utilissima* and *M. glaziovii*.

The mycelium forms brownish patches over the surface of the leaf. The small spherical reddish brown fructifications appear on these patches and mostly on the under side of the leaf.

OPHIOBOLUS HEVEAE

A disease caused by the fungus *Ophiobolus heveae* P. Henn. was reported by Hennings on Hevea from a collection made by Ule at Sao Joaquim on the Rio Negro in February, 1902. Gray patches appear on the surface at the margins of the leaves and finally fuse, covering the entire leaf. On the under side of the leaf the mycelium becomes brownish and the leaf soon dies. The small black fructifications appear on the gray patches on the upper side of the leaf.

RIM-BLIGHT

The term "rim-blight" has been employed in the East to describe a form of leaf-blight which extends partly or all around the margin of the leaf. This form of leaf injury was found at several localities in the Amazon Valley but appeared to be of little or no consequence. Since the margins are the only part of the leaves affected the disease is very conspicuous (Pl. XVIII, A). This blight makes its appearance as small irregular brownish spots at the edge of mature leaves. The edges later turn a lighter brown than the spots and curl to the

upper side. The disease does not appear to make further progress after this stage. The leaf remains attached for some time but falls prematurely. The diseased tissues contain hyphæ, but the fruiting fungus was not found.

Petch has recorded three rim-blights in Ceylon, each being referred to a different organism. In no case were they reported to cause serious damage.

INDETERMINATE LEAF-SPOTS

It has not been possible to determine with any degree of satisfaction the causal organism of a number of common leaf-spots found on Hevea. It is doubtful whether all of these pathological appearances are to be attributed to parasitic fungi. Usually two or more fungi may occur in association with the spots, and these may be merely saprophytic on the dead tissues. Not until it is possible thoroughly to investigate the fungi experimentally in the field, in cultures, and by inoculations will the subject be elucidated. Some of these spots from their frequent occurrence and evident ability to destroy the leaves are of considerable economic importance. Others appear mainly at about the time of normal leaf fall and probably somewhat hasten the process. One such spot was frequently found on leaves under heavy canopy. Small yellowish translucent spots from 1 to 5 millimeters in diameter appear as a first stage. In the center of the yellowish areas dark reddish brown spots appear, and the leaf assumes a light-purple color. When the leaf is held to the light the spots are very conspicuous. The purple color of the leaf deepens to reddish purple, the yellow border may appear greenish, and the central spot becomes black, with the development of a white superficial mycelium. A peculiar effect accompanying this disease is the chlorotic appearance of considerable areas of the upper side of the leaf, making it opaque to transmitted light. The organisms found associated with this leaf-spot are *Fusarium heveae*, *Zygosporium* sp., and occasionally *Scolecotrichum heveae*.

Another disease common to mature leaves took the form of small purple spots from 1 to 3 millimeters in diameter, never larger, with light gray centers (Pl. XVIII, A). The centers eventually fall away, leaving holes with purplish red borders. The disease resembles on a small scale the large reddish leaf-spot caused by *Phyllosticta cinerea*, but the organism found on the margins of old spots was referable to *Cercospora heveae*.

In the examination of spots with purple-brown margins about 1 to 4 millimeters in diameter on young leaves, spores were found which conformed to the characters given for *Helminthosporium heveae*, but there was little evidence that this was the causal organism. Similar effects were very plainly the result of insect punctures.

BLACK MOTTLING OF LEAVES

It is a common experience to find the leaves of Hevea in the forest affected with what appears to be a thin sooty film. A close examination, however, shows that the film is not superficial but consists of dark-colored irregular-branched hyphæ of short contorted cells beneath the cuticle of the leaf. It is visible on the surface and

appears as a thin film. The hyphæ also invade the mesophyll and are found in the vascular system of the midrib and veins. The invasion of the hyphæ is not uniform under the epidermis, but appears as irregular patches, giving the leaf a mottled appearance. This is especially striking on the petioles, where there is a greater contrast between the lighter colored epidermis and the sooty colored hyphæ. On the petioles the hyphæ may also appear on the surface, and in the region of the nectaries at the base of the leaflets they may entirely obscure the tissues beneath.

Small black spherical fructifications are enmeshed in the submerged hyphæ and may appear on both sides of the leaf. They may be especially numerous in the tissues in the region of the midrib. They are visible through the epidermis. The hyaline spherical to elongated spores are expelled in a gelatinous mass through a small opening projecting through the epidermis. The fruiting stages of the fungus in the material examined appeared to be immature, and it has not been possible to determine the organism satisfactorily. The fungus is also found on young green pods. The species is in no wise associated with scale insects.

The fungus from its endophytic habit is a parasite and in later stages of infection probably causes some injury to the leaves and fruits.

SOOTY MOLD

In damp situations the leaves of seedlings or of larger plants when growing under heavy canopy are frequently grown over with a black mold (*Capnodium* sp.). The mold is entirely superficial and may be peeled from the surface of the leaf, or it will flake off when the leaves are dried. The fungus develops in a sugary solution deposited by insects or mealybugs. These insects may produce the solution in such quantity that it drips over the stems and leaves of the plants, furnishing a rich substratum for the propagation of the fungus. The spores of the fungus are caught in these drops or on the film formed over the substrata, develop luxuriantly, and soon cover the surface of the leaves and stems.

The crust is composed of a basal layer of septate brown hyphæ, often extensively branched. The cells of these hyphæ are often very irregular and conspicuously constricted at the septa. The hyphæ less united with the basal layer break up and form chains of simple spherical brown conidia, or sometimes they are formed in globose masses, gemmiform and variously septate (Coniothecium). In some forms the conidia are uniseptate or in pairs. In the form most commonly observed elongate-ovoid septate (Brachysporium) or stellate septate (Triposporium) conidia were observed. These conidial forms are capable of germination and when blown about by the wind rapidly extend the fungus. A pycnidial stage is sometimes produced, the pycnidia being usually in the form of a straight or curved cylinder slightly swollen at the base and open at the tip. The pycnidia are filled with small hyaline elliptical to ovate 1-celled spores. The perithecial or ascigerous stage less commonly observed in these molds is usually in the form of a globose body with a thick stalk or is flask shaped with a fringed opening.

The asci are irregular, usually rounded, and contain four to eight brownish green septate ascospores.

The great variability in the spore forms found in different collections, together with the absence in most cases of the ascigerous stage, has made it impossible in some cases to refer definitely the organisms. The forms most commonly observed have been referred to *Capnodium brasiliense* and *C. lanosum*.

A species of Meliola forming thin sooty spots on the young leaves of Hevea is of common occurrence in very wet situations. The material was immature and did not conform to the description for *M. hereae*. Hennings also reported a species of Meliola which he considered related to *M. amphitricha*.

The injury resulting from the growth of sooty molds is of slight degree, but if the incrusting hyphæ remain on the leaf for protracted periods, thereby shutting off the light from the chlorophyllaceous cells of the leaf, some damage may result. The leaves lose their green color and eventually fall. In damp shady situations during periods of little rainfall trees under heavy canopy may be defoliated, causing an infection of twigs by secondary fungi. The growth of the fungus is closely associated with the honeydew of insects; hence the obvious method of control is to destroy the insects by spraying with kerosene emulsion. The fungus is common on jungle trees and bushes. It would be good practice to remove heavy jungle growth from the near vicinity of rubber trees.

ENTOMOGENOUS FUNGI

In contrast to the sooty molds there are several parasitic fungi which prey upon insects secreting honeydew. They may be considered beneficial by destroying insects which otherwise may cause injury to the leaves.

One of the most common species of this group sometimes found on young and old leaves of Hevea is *Hypocrella reineckiana*. This fungus usually in its lower or Aschersonia stage develops over the body of a single insect, forming boat-shaped or spherical nodules. They are attached to the upper side of the leaf by a flattened base and may be easily removed. These nodules are usually strikingly colored with shades of yellow, brown, or orange when young, but become black when old. Internally they are yellow or orange colored. The fungus is entirely parasitic on the scale insect and does not affect the leaf.

Several different species of scale insects were found on leaves of Hevea, and they were in most cases parasitized by fungi. The fungus either envelops the entire insect, as in the case of the above-named species, or grows out around it, forming a white fringe. *Cephalosporium lecanii*, Aschersonia, Aleyrodes, and *Hypocrella verruculosa* were also found on scale insects on Hevea.

EPIPHYTIC AND PARASITIC ALGÆ ON LEAVES

On the smooth, hard, polished upper surface of leaves and on stems of many species of jungle trees are found reddish, greenish, or whitish flattened scurflike thalloid patches. These patches are the fructifications of epiphytic and parasitic algæ. The surface of

thick heavy evergreen leaves may sometimes be almost obscured by these patches. The two following species were more or less common on Hevea.

GREEN-SCURF DISEASE

In the disease known as green-scurf (*Cephaleuros virescens* Kunze) the patches are slightly raised above the surface of the substratum. In later stages a false epidermis is formed, which fuses with that of the leaf. The patches consist of a lobed or branched thallus, composed of cells arranged in rows radiating from the center. The patches are at first smooth and gray-green with small black spots (Pl. XVII, A), and they are usually very firmly attached by means of branched rhizoids. Later, the surface is covered with numerous erect septate orange-colored hairs, some of which terminate in sporangia and some as sterile projections. The sporangia, green when young, orange when old, are carried by the wind or rain to other leaves or plants, where they give rise to motile biciliate swarm spores (zoospores). These may swim about in a drop or film of water and start new colonies. The algal colonies are frequently parasitized by fungi.

The species has been noted on a number of plants in the Tropics. Among them are *Persea gratissima*, *Achras zapota*, *Bischoffia japonica*, *Chrysobalanus icaco*, *Cinnamomum camphora*, *Citrus aurantifolia*, *C. limonia*, *Gardenia jasminoides*, *Hibiscus* sp., *Magnolia* sp., *Mangifera* sp., *Ocotea leucoxylon*, *Psidium guajava*, and *Viburnum tinus*.

On the leaves of *Hevea guyanensis* the colonies may sometimes be very conspicuous, but on *H. brasiliensis*, owing to the more delicate structure of the leaves, the algæ are not so noticeable.

On the twigs the patches may attain a diameter of 5 millimeters or more, but they rarely spread uniformly over the surface. The organism is epiphytic and causes little more than a brown spotting of the substratum directly beneath the patch. The effect is rarely visible on the lower side of the leaf.

RED-SCURF DISEASE

The species causing the disease known as red-scurf (*Cephaleuros parasiticus* Karst.) differs from *C. virescens* in being a true parasite, living entirely within the tissues of the host plant (entophytic). The disease first makes its appearance as small translucent spots, usually on the upper side of the leaf. The alga then spreads through and fills the cells of the host, causing hypertrophy and death of the tissues. On the lower side of the leaf the spots are usually more elevated, irregularly lobed at the margins, and appear purplish red through the grayish epidermis of the host (Pl. XVII, D). On the upper side of the leaf the spots are purplish red, becoming black and sunken in the center with an irregularly lobed red or purple margin. In old stages the spots on the upper side have the appearance of dried blood. The epidermis is ruptured on both sides of the leaf and the stalked septate sporangiophores bearing the sporangia appear. These form a yellowish to reddish hair-like coating over the spot, or they may be grayish when old. The

swarm spores are liberated through a longitudinal split in the sporangium and are washed by dew or rain over the surface of leaves and young stems and enter the host through the stomatal openings. Here by division of their cells a new thallus is produced. The influence of the parasite may extend considerably beyond the zone of actual infection, causing the formation of deposits in the cells of the mesophyll. The deposits, at first reddish, are black when old. The algal cells in the tissues are green in early stages of infection but are reddish when older and give the general red color to the spots. A layer of algal cells may develop between the epidermis and the mesophyll, causing the latter to crack and blacken.

The parasite was found on both healthy plants and those weakened by various causes. The injury results in the destruction of the leaves and shrinkage of the stems.

FRUIT AND FLOWER DISEASES

PHYTOPHTHORA POD-ROT

A Phytophthora disease (*Phytophthora faberi* Maubl.) of the pods of rubber was found near Utinga at Para during the heavy rains in November. It was characterized by a sodden greenish watery discoloration of the outer fleshy wall at the base of the stem. From this point it extends along the line of sutures between the lobes of the pod to the distal end. Here the three zones of infection meet and spread to the sides, the entire green outer fleshy wall of the pod becoming soft and rotten, so that the epidermis can be slipped off with the thumb. The decay rarely begins at the distal end or on the sides of the pods. The discolored zones between the lobes of the pods soon develop a whitish or grayish film, which extends over the entire pod as the rot advances (Pl. XVII, C). Before the pod begins to shrivel the fleshy wall cracks open along the grooves, beginning at the stem. The woody wall beneath does not open until some time after the outer wall becomes dry and shriveled. The seeds, which are immature when infection occurs, are hollow and decayed. The dry shriveled pods may either fall from their stems by the subsequent spreading of the woody wall or they may remain attached to the tree indefinitely. Old dried pods from infections of previous seasons were frequently found attached to the trees. There was no evidence that the disease extended to the twigs or young shoots. The fungus is very destructive to cacao pods in the Amazon region and is no doubt the most common source of the inoculum on Hevea. In some of the cacao plantations visited as high as 50 per cent of the pods were destroyed while still young.

If the white surface mycelium on the pods is examined it is found to consist of nonseptate hyphæ of varying diameters. In the larger intercellular spaces the hyphæ are fusiform or pouchlike, becoming reduced in the narrower spaces or where they penetrate the cells. The hyphæ later rupture the epidermis, emerge, and form on the surface a network of delicate unbranched sporophores. On the ends of the sporophores small hyaline egg-shaped sporangia are produced with papillate openings at the apex. The sporophores continue to develop, pushing aside the original sporangium when another is

produced, and so on. This method of reproduction is characteristic of the group. Rarely sporangia are borne on short lateral branches. The sporangia on germination give out a number of oval or elliptical hyaline zoospores. The spores are provided with two motile cilia, by means of which the spores are propelled in a drop or film of water, as that of a leaf after rain or where covered with dew. After a time they come to rest and send out delicate germ tubes which penetrate the epidermis either through the stomata or directly through the cell walls.

Another type of sporangium is produced either on the external mycelium or internally which does not give rise to motile zoospores but germinates in the ordinary way. These spores develop a thick wall and are capable of tiding the fungus over periods of dryness. These resting spores may be formed in great numbers in the diseased tissues of the fruit and are liberated when the tissues decay.

A third type of spore may be produced by a sexual process wherein the male-element antheridium, a globular or oval body, fertilizes the oogonium, usually a pear-shaped smooth or rough-surfaced hyaline structure, which represents the female element. The result of this process is the production of thick-walled smooth brown oospores, which germinate under suitable moisture conditions. This structure has not been observed for the species.

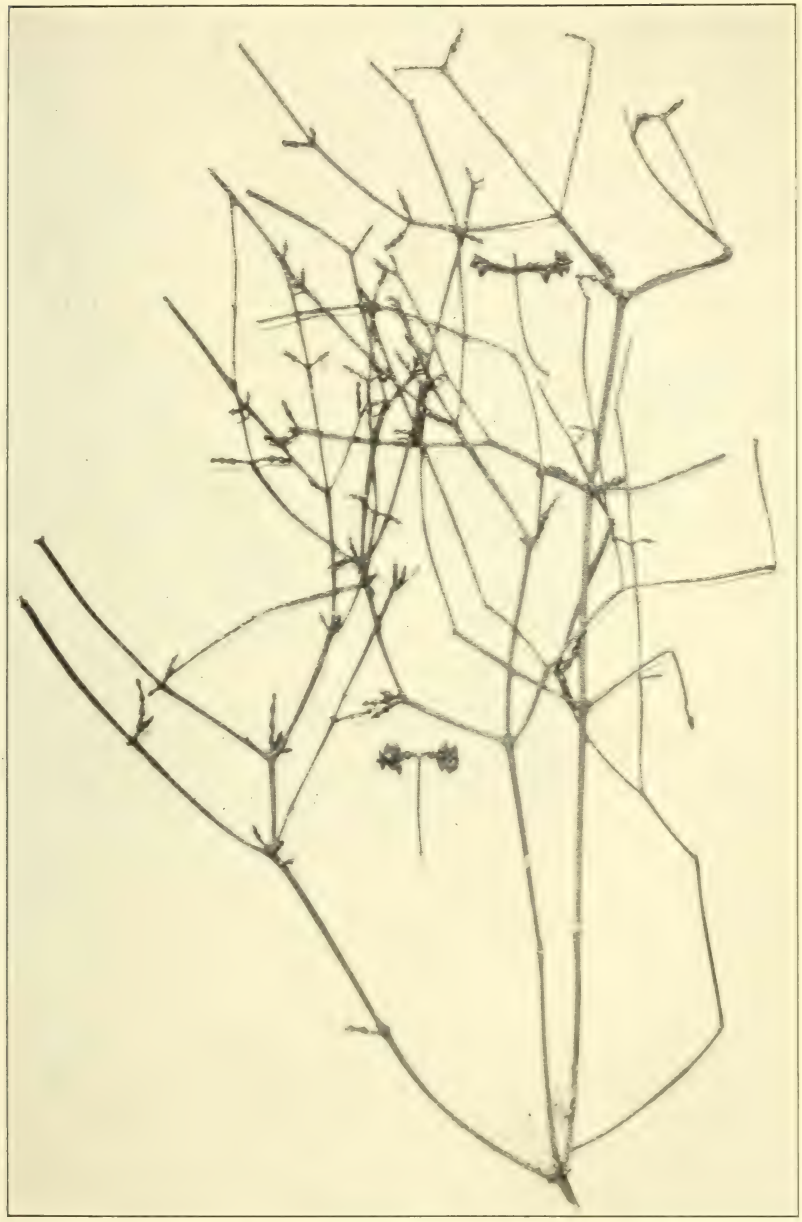
When the diseased fruits begin to shrivel, or even before, the original cause of the disease is entirely obscured by the rapid attack of a number of secondary fungi. Among the first to appear is *Gloeosporium alborubrum*. The pink spore pustules of the fungus sometimes appear in great numbers and may be confined to areas of the surface not overrun by the Phytophthora. There is some evidence that Gloeosporium may also cause a disease of the pods. Yellowish green pods picked and placed in oil-paper bags for a few days would become completely covered with the pink spore masses. The fungus appeared to be omnipresent, however. Perfectly green and healthy pods when kept for a few days in a closed jar developed the spore masses in great numbers.

The Gloeosporium is rapidly obscured by an excessive development of Diplodia and various molds.

FLOWER BLIGHT

The inflorescence of Hevea is frequently attacked by *Dothidella ulei*. All parts of the inflorescence are attacked, causing them to shrivel and fall away. Heavy infections were observed in the region of Para but none on the upper Amazon. The destruction of the flowers naturally affects seed production. The seeds are not of economic importance, but the significance of the attack has a bearing on the maintenance of the fungus in the stand by increasing the amount of infectious material.

In two different cases the floral spikes of Hevea in situations where they were crowded against withered or decaying vines were overrun and blighted by various species of Aspergillus. (See list, p. 80.) This is but a temporary condition and is of no economic importance.



DENDROPHTHORA POEPPIGII, THE COMMON MISTLETOE OF HEVEA

PHORADENDRON CRASSIFOLIUM ON HEVEA

ORYCTANTHUS BOTRYOSTACHYS ON HEVEA

PHTHIRUSA ADENOSTEMON ON HEVEA

MISTLETOE PARASITE AND WOUND INJURIES OF HEVEA

A, *Phthirusa pyrifolia;* B, unsuccessful treatment of a root by tree-surgery methods, showing also the eastern method of tapping

PHTHIRUSA AMAZONENSIS ON HEVEA

PHTHIRUSA BRASILIENSIS ON HEVEA

DENDROPHTHORA POEPPIGII INFECTION IN THE CROWN OF HEVEA

Note the dead branches, the swelling on branches, and the reduction of foliage

DENDROPHTHORA POEPPIGII INFECTION ON A HEVEA STEM

The formation of burl and the roots of the parasitic plant embedded in the wood are shown

INJURIES TO HEVEA BY PHANEROGAMIC PLANTS

A, *Dendrophthora poeppigii* infection on a branch, causing swelling and the death of the branch beyond the point of infection; B, *Phthirusa brasiliensis* in the crown of a young tree; C, a young tree supporting a colony of *P. brasiliensis* which has killed the stem above the seat of infection

EFFECTS OF DENDROPHTHORA POEPPIGII ON HEVEA

A, Formation of elongated burls and branch stubs; B, burls in which the parasite is living without aerial parts

EFFECTS OF BROWN BAST AND TAPPING CUTS ON HEVEA

A, Circular callus nodules or plates formed over tapping cuts; B, nodules formed in the cortex affected with brown bast; C, scaly bark and brown lines in the cortex due to brown bast. (Natural size)

INJURIES CAUSED BY PHANEROGAMIC PLANTS

MISTLETOES

The mistletoes (Loranthaceæ) are very common throughout the Amazon Valley, attacking a great variety of trees and shrubs. Young mistletoe plants in the first cotyledon stage have even been found on such temporary substrata as the fruits of the banana, papaya, breadfruit, avocado, and soursop. Aside from the numerous species which are usually found on trees, vines, and shrubs in the forest, some of which are occasionally transferred to Hevea, certain other species show an affinity for some of the horticultural plants.

Cacao is attacked by *Phthirusa pyrifolia* and *Oryctanthus ruficaulis*. Oranges and limes are attacked by both the above-named species and by *Phthirusa brasiliensis*. The mango is frequently attacked by *Phthirusa pyrifolia*.

Struthanthus flexicaulis, a vining species, is of common occurrence on both the wild and planted cashew. It was found growing over Hevea from these hosts but not from original infections. *Oryctanthus botryostachys* is of considerable importance on the avocado. Since these trees are frequently planted in association with Hevea it is not surprising that some of these mistletoes are occasionally transferred to the latter. They are not, however, the species usually found on Hevea, and when they do occur it is probably the result of an accidental infection.

Seven species of mistletoe were found on Hevea. They are *Dendrophthora poeppigii* (*D. heveicola* Ule) (Pl. XIX), *Phoradendron crassifolium* (Pl. XX), *Oryctanthus botryostachys* (Pl. XXI), *Phthirusa adenostemon* (Pl. XXII), *P. pyrifolia* (Pl. XXIII, A), *P. amazonensis* (Pl. XXIV), and *P. brasiliensis* (Pl. XXV). The last two are believed to be new to science.

Of these seven species *Dendrophthora poeppigii* may be considered the typical mistletoe of Hevea. It was constantly confined to this host and was the cause of considerable damage in several parts of the valley. This mistletoe, with its pinkish red berries and greenish yellow leafless stems, is very conspicuous on Hevea, and more especially so during the period of leaf fall (Pl. XXVI). The species resembles some of the leafless Phoradendrons. It was originally described by Ule as *Dendrophthora heveicola*.

In his original report on the Amazon Valley, Akers evidently refers to this species and states that "in many districts a parasitical growth not unlike mistletoe was found on the trees, and this is difficult to eradicate owing to its growth on the upper branches where it can not be reached with ordinary appliances." Referring to this species Akers later states—

> This pest is found throughout all sections of the Amazon Valley. Its effects are most apparent on old trees, and from these it draws out all the vitality, until branch after branch dies away and the tree is killed. It has most tenacious roots, spreads rapidly once it has established a footing, and is often propagated from seeds dropped by birds and lodging in crevices of the bark or in joints where moisture has collected. * * * In every district the annual loss from this plague amounts to many thousands of trees.

This statement is much overdrawn, but the fact remains that considerable damage may result if the ravages of this species should extend to plantations and not be controlled.

The Loranthaceæ are chlorophyllaceous plants. They obtain their supply of water, nitrogen, mineral salts, etc., from the host. This material is elaborated in the stems or leaves in the same manner as in other green plants. They are consequently semiparasitic. The degree of parasitism, however, varies with the species. In some the amount of chlorophyll is much less than in others. The reduction of chlorophyll, together with the absence of leaves, develops a parasitic condition much greater than is the case in the green-stemmed leafy species. *Dendrophthora poeppigii* belongs to the former group and is comparable to the strongly parasitic species of Razoumofskya, so destructive to conifers in the western United States. In fact, both are capable of maintaining their existence in the wood and bast without aerial parts during the entire life of the hosts. This requires a completely submerged root system. In contrast to most tropical loranths, which send out roots from the gnarled point of attachment along the outside of the branch, giving off at short intervals stout suckerlike roots which penetrate the cortex, the Hevea mistletoe sends its roots directly into the cortex at the point of the germination of the seed and does not later produce surface roots. This is characteristic of all species in the Temperate Zone and results in the formation of burls and cankers and causes the death of branches beyond the point of infection.

The seeds of the mistletoes are provided with a mucilaginous coating which causes them to adhere to any object upon which they may fall or may be placed. The primary root of the germinating seed develops a terminal disk or sucker which is pressed firmly on the substratum. From the center of this sucker a root or sinker appears which penetrates the cortex. It is a very delicate structure and terminates its apical growth when it reaches the wood. This root, however, is provided with meristematic tissue in the region of the cambium of the host. By intermediary growth the root is able to elongate at the same rate as the increase of the branch in thickness. As the apex of the root is buried deeper each year by the increased increment of the host, the root appears to have actually forced its way into the wood (Pl. XXVII). These roots remain functional for a greater or lesser period of time, depending on the nature of the substratum. Frequently in the beginning they are joined with the medullary rays and function for a longer period. Sections through the wood of the host show these roots in various stages of growth and disintegration. In the region of the fast, lateral roots grow horizontally from the original root, and a network of cortical stroma is developed which stimulates the host tissues to form abnormal structures. This eventually results in the formation of dead wood and open cankers, to the great detriment of the host.

The general nature of the injury by mistletoes on Hevea is expressed in a gradual reduction of the leaf surface of the host, which causes a reduction of growth in height and diameter. New infections take place through the agency of a germinating seed, which reaches the point of infection usually through birds, which use the pulp of the berries for food, or by the extension of the submerged

root system. The berries may also fall to lower parts of the tree from the infected branches higher up, or they may be carried by animals. Trees of all age classes are liable to infection, provided the mistletoe seeds reach parts of the host not yet protected by mature cortex. The parasite may spread from the original point of infection into older cortical tissues which are not liable to infection from without. Excessive mistletoe infection of the lower branches of Hevea may cause the upper portion of the crown to die, giving rise to the phenomenon commonly called staghead. Severe infection throughout the entire crown may result in a reduction of yield and eventual death of the tree (Pl. XXVI). Infection on the branches causes the formation of abnormalities and the death of the branch beyond the point of infection, leaving club-shaped stubs (Pl. XXVIII, A). Infection on the main stem at an early age results in the formation of burls (Pl. XXVII) and contorted trunks (Pl. XXIX, A and B). The weakening effect of the formation of these burls is often responsible for the infection by *Nummularia anthracodes* and other weak parasites and insects.

The mistletoe next in importance on Hevea is *Phthirusa brasiliensis*. This is a leafy species and for that reason is often very conspicuous when perched high in the crown of its host (Pl. XXVIII, B). Young Heveas have been observed to support a colony of this mistletoe after the parasite had caused the death of all parts of its host above the seat of infection (Pl. XXVIII, C). This illustrates a very interesting relation between host and parasite. The host, however, must eventually succumb to the attack.

Although mistletoe was common on Hevea in the forest it is not likely to be of much consequence on plantations. The parasite may be controlled by keeping a sharp outlook for early infections and removing the infected branches. This will prevent a center of infection from forming in the plantation. The action of the parasite is slow except on young trees, and before any serious damage results the infections may be removed. Mistletoe infections on associate crops should be eliminated; likewise, those on surrounding forest trees if the species prevalent is prone to attack Hevea. The parasite dies with the death of the host; hence, it is not necessary to burn lopped infected branches except from the standpoint of general sanitation.

The mistletoes in the Amazon Valley are subject to various fungous diseases, and the leaves and stems support a number of mosses, lichens, and algæ. None of these organisms, however, greatly affect the vigor of the parasites.

It is interesting to note that the seeds of some mistletoes found on Hevea and jungle trees contain as high as 20 per cent of their dry weight of almost pure rubber. The practical significance of this fact was discussed by Warburg in the Tropenpflanzer in 1905.

DAMAGE CAUSED BY LIANAS AND OTHER VINES

Lianas and other vines occasionally cause injury to young Hevea in the jungle by winding around their trunks. As the tree increases in thickness the cortex is subjected to pressure, with the result that the vertical descent of food substances is forced to take a spiral course. This causes the transporting tissues to change from the

vertical and to develop spirally. A ridge is formed on the upper side of the vine and there is a corresponding stagnation of growth on the under side. If the vine is small it may be completely overgrown in parts, giving the tree a spirally fluted appearance.

Clinging vines were observed in a few instances to interfere seriously with the development of the crowns of young Hevea, causing suppression. On neglected plantations and in the jungle these conditions may be expected.

ORCHIDS AND AROIDS

Perched upon the branches or attached to the trunk of Hevea various species of epiphytic orchids, aroids, and other flowering plants were occasionaly observed. No damage resulting from such growths was encountered. The compact root masses of many of these plants harbored large numbers of ants. The white ants occasionally extend their runs to these clumps, and for this reason the plants should be destroyed on all well-regulated estates.

PHYSIOLOGICAL DISTURBANCES AND ABNORMALITIES

BROWN-BAST

The brown-bast disease, which is the cause of much damage in eastern rubber estates, concerning which an extensive literature has developed, occurs in the American Tropics, but apparently in a mild form.

Dr. Carl D. La Rue discovered near Para a tree which exhibited all the symptoms usually attributed to this disease, and the writer located several others in the same locality. These trees, which averaged about 14 inches in breast-high diameter, had been excessively tapped by the usual method, whereby a small ax is driven through the cortex into the wood. The wounds in healing had produced numerous callous formations, a result which usually follows this mode of tapping. It was noted that the cortex around some of the unhealed wounds did not produce latex, appeared watery, and was of a yellowish gray color intermixed with brownish spots. Since these symptoms indicated the presence of brown-bast a close examination of several trees was made. The trees had all been tapped in the manner described above, and all had produced numerous small nodule and callous formations. These formations in some cases were unusually large and conspicuously roughened. The small nodules usually were lightly attached and could be removed with the fingers. Out of five trees discovered with brown-bast symptoms a considerable variation in the appearance and location of the discolored areas in the cortex was noted. A peculiar feature was the breaking up of the surface bark in the form of brittle scales. When shaved down smooth with the bark their location and outline were well defined (Pl. XXX, C). These scales with their margins defined and slightly raised were firmly attached in the center. When pried off with a knife a greenish yellow watery appearing surface was exposed. A cut on this surface appeared dry without a flow of latex. Owing to the irregularities of the bark due to callous formations these scales were never more than 2 or 3 inches in diam-

eter and were usually confined to the areas between the calluses. On the surface immediately beyond the tapping cuts, the scales were larger. By shaving off the exposed tissues, grayish yellow spots or reddish brown streaks were exposed. These discolored spots were of varying depth in the cortex and were rarely united to form a continuous brown line. This brown zone when present was next the cambium and was usually separated from it by a narrow laticiferous layer (Pl. XXX, C). This layer was separable from the cortex along the brown line. In the worst cases examined the isolated discolored areas external to the brown line had become confluent in one plane, so that the cortex in radial sections gave a banded or zoned appearance. Later, these bands became fused, so that the entire cortex was uniformly brown. This occurred only in patches varying from half an inch to 3 inches in diameter and was especially marked in the cortex covering the callous nodules. By shaving off the surface dead cortex these reddish brown areas were exposed. In late stages the tissues of these areas become hard and brittle and separate from the rest of the cortex. They may be removed, exposing the white laticiferous layer beneath. The latter may be normal or not, according to thickness. A fact of interest was noted in that occasionally small elongated nodules had developed beneath these scales or at the margin of the depression. These nodules had developed a new cortex and were entirely separated from the surrounding tissues (Pl. XXX, B).

The disease was not found on untapped trees and was by no means common on the tapped ones. Only on those that had been excessively mutilated could the disease be expected to occur. In one such case the disease was present from the ground level and for 3 feet above the last tapping cut, a total distance of about 15 feet.

In all cases the vigor of the trees appeared to be in nowise impaired. The cambium in every tree examined appeared to be healthy. The failure of the cortex on some of the large callous nodules, leaving the wood exposed so that it had become hard and weathered, was apparently the only permanent form of injury aside from the general mutilations by the ax that the trees had suffered.

Although the cause of brown-bast has not been discovered, it would appear from the investigations that have been made by Rands, Bobilioff, and others that it is a physiological degeneration of the tissues resulting from tapping and the extraction of the latex.

From the fact that the disease is very widely spread in the East it is believed that it may become more pronounced in the American Tropics when the eastern tapping methods are employed. There is no reason to think that the tree has undergone any physiological change from being planted in the East that would make it more susceptible to the disease in that region.

One very interesting and important fact must be considered in judging the presence of brown-bast in the Amazon Valley, viz, the great variation in the normal color of the tissues of the cortex. Several varieties of rubber trees based on the color of the bark are recognized. These are the black (preta), the white (branca), the red (vermilha), the barriguda (*Hevea spruceana*), and the Itapuru (*Hevea guyanensis*). On the basis of resiliency the rubber of these several varieties is rated differently commercially. That from the

black Hevea is classified as fina and that from the others as fraca (weak). There is considerable confusion in the application of these color terms. In one part of the valley the terms refer to the outer color of the bark; in another they apply to the color of the tissues of the cortex. To eastern investigators who have been more accustomed to the light-colored cortex it must be a matter of surprise to find that most of the trees growing on dry land (terra firma) have a reddish colored cortex tinged with brown or purple. Such colors when known only in association with brown-bast would lead to confusion until the varieties are learned. In the lower Amazon region, where many trees grow on swampy land or where the land is subject to frequent inundations, the variety with light-colored cortex predominates. It was from this variety with a few exceptions that the seeds were obtained to establish the plantations in the Orient.

From the standpoint of preliminary observations on the presence of brown-bast in the Amazon Valley the normal color of the cortex should be held in mind. In the white variety the color changes induced by the disease are readily apparent. So far as the investigations were carried, the symptoms of brown-bast were observed only in the white variety, which leads to the conjecture that this form may be more susceptible to the disease. On a living Hevea stump with the red-colored cortex rough bark scales were apparent. These when removed showed a watery, sodden appearance beneath, without color change. The tissues thus exposed were laticiferous. Further study is necessary to determine the reactions in cortex of this color.

WOUNDS

Numerous kinds of wounds found on Hevea may be roughly divided into two groups: Those which result from the natural processes of growth, frequently intensified by adverse conditions, and those resulting from external causes.

Before the different kinds of wounds found on Hevea in the Amazon Valley and their effect on the health of the tree are described it seems desirable to discuss the natural processes by which the tree attempts to restore its injured parts.

The tissue concerned in the protection of the living cells of young twigs and stems is a thin layer of epidermis, the periderm. When the periderm ruptures through the increased growth of the parts beneath, its cells or those of the phellogen (cork cambium), situated beneath the periderm, divide tangentially, and a new protective covering is immediately formed over the living tissues. The renewal of this protective layer by the cork cambium on its inner surface and the cutting off of cells which soon lose their power of division on its outer surface are constant processes and result in the formation of an outer layer of dead cork or, as it is called, the bark. The entire structure is known as the cortex. The meristematic nature of the cork cambium beneath the outer dead bark is the mechanism which produces a protective layer when wounds are formed in the cortex. In such cases the protective layer is known as wound cork and may be very rapidly developed, especially at the edge of wounds which have exposed and killed the true cambium.

If a wound exposes the true cambium one or more of several sets of tissues begin to repair the damage. Tyloses, or filling cells, are developed in the outer exposed vessels of the wood, which is the only reproductive ability the woody cells possess.

The cambium, if uninjured by drying through exposure, by the transverse division of its protoplasmic cells soon forms an investing tissue, which under the influence of the sun becomes chlorophyllaceous. The epidermis then develops, and the work of protecting the living tissues beneath is carried on by the cork cambium above described. If the wound is formed during the dry season the cambium may be destroyed with the exception of the parenchymous cells of the medullary rays. These cells of the wood, which retain their ability to divide, now take up the work of protecting the exposed tissues. Small areas of healing tissue appear over the surface of the wound, which later coalesce and cover the surface completely. Whether the new investing layer is formed by the cambium or by the cambium of the medullary rays, it is at first of a homogeneous structure. With the development of the periderm and the cutting off of an outer protective layer by the cork cambium separating the outer or cortical layer from the bast region, which in turn is separated from the wood by the meristematic cambial zone, the usual differentiation of tissues is restored. The cells of the new wood formed on the wound, however, are of an abnormal structure, and from this fact the location of old wounds may be recognized years after all external signs have disappeared. This is especially shown in trees which have died from excessive tapping and have split up in falling.

If the cambium is completely destroyed before a protective layer can be developed over the wound or if the wood is exposed by natural or artificial pruning of branches or tapping through to the wood, the only healing process that is possible is the formation of a callus from the edge of the wound. This is brought about by the rapid development of the cambium at the edge of the wound. The callus advances from all directions and finally coalesces in the center. The exposed wood of the wound which has become discolored is merely inclosed by the callus. If it is infected with a wood-destroying fungus it may result in serious damage to the tree. Certain natural processes may tend to inhibit infection. The wood cells may become filled with tyloses, viz, ingrowths of the cells, which may effectually plug the lumina against the invasion of water. Gums may form over the surface of the wood and act in the same way as tyloses. The oxidation of cell substances resulting in discoloration of the wood is often deceptive and may not indicate decay by a wood-destroying fungus. Whatever natural processes may take place in Hevea they are not sufficient to protect open wounds from infection, and artificial treatment must be employed. This will be discussed later.

KINDS OF WOUNDS

NATURAL WOUNDS

In a hard, compact soil the lateral roots of Hevea sometimes cross one another near their point of origin, become fused below, and form bowllike or triangular-shaped cavities. These cavities are con-

stantly filled with rain water and vegetable débris or may support epiphytic plants. In two such cavities encountered it was found that the cortex had broken down, presumably under the combined influence of poisonous substances and fungi. The wood was decayed around the sides of the cavity. The sporophores of *Polyporus zonalis* were present in one instance and those of *Fomes hornodermus* in the other.

The development of three main branches sometimes occurs in Hevea, resulting in the formation of a deep crotch. If the branches are inclined to the vertical, as frequently happens, there may be an accumulation of materials, such as dirt in the form of dust washed down from above, dead bark scales, and the seeds of epiphytic plants. This accumulation may result in damage to the tree, in that it promotes the development of fungi which may find entrance at this point, especially if the interference of the branches has resulted in a deep crack. The swaying of the branches by the wind may open the crack to the wood, with serious consequences. A crotch of this kind was opened with an ax, and the crack was found to extend to the wood. The wood was discolored and infected with an undeterminable fungus. This condition may occur, but to a much less extent, in trees with only two main branches. It is the practice in the East to clean up these forks, since the condition is believed to facilitate the entrance of fungi. In this connection Akers, writing of canker on Hevea in the Amazon Valley, states that "it is found generally at the junction of the main lateral branches with the trunk, where a lodgment of rain water has taken place. The effect is to rot both branches and stem until the tree becomes exhausted and dies." No such serious condition was encountered during the present investigation, but under plantation conditions it would be well periodically to clean and sterilize the forks.

One of the most common natural wounds occurring on Hevea in the forest and in closely planted estates is the suppression of lower branches by shade. The loss of light due to the increase of the crown above causes the lower branches to become greatly reduced in vigor, which ultimately results in death. This process is usually hastened by the action of numerous semiparasitic and saprophytic fungi. When the branch is decomposed it falls from the tree, leaving a projecting stub, or, if the decomposition is very complete, a hole in the tree. In either case wound fungi or those which aided in the decomposition of the branch advance within the knot and attack the wood of the trunk. The death of the lower branches may be expected when their twigs and leaves are killed by parasitic fungi. Species of fungi which have been collected on dead suppressed branches causing a decay within the knot are numerous. The most common are *Trametes hydnoides*, *T. rigida*, *T. corrugata*, *Lenzites striata*, *Odontia* sp., *Polystictus atypus*, *Stereum papyrinum*, *S. umbrinum*, *Schizophyllum commune*, and *Corticium* sp.

The hollowing out of the knot by these fungi prevents the even formation of an occluding callus, which usually in such cases curves inwardly, delaying the complete closing of the wound. Hollow knots may reduce the mechanical strength of the tree and cause its overthrow by wind.

In the case of Hevea the base of the branch rarely dies, so that its tissues are in intimate connection with infectious wood of the branch. This may lead to the gradual infection of the bark of the trunk by slow parasites. In this manner *Diplodia theobromae*, *Stereum umbrinum*, *Nummularia anthracodes*, Ustulina, and other species have been found advancing on the bark of the trunk.

All naturally pruned branches or their stubs should be removed as soon as possible and the surface of the exposed wood treated with antiseptic substances. (See "Protection of wounds," p. 66.)

MECHANICAL WOUNDS

Callous formations.—The system of tapping in vogue in the Amazon Valley is responsible for more injury to the tree than all other causes combined (Pl. XXXI, A). The method may be briefly described. The seringueiro, or rubber collector, employs a small ax, known as a machadinho, to make the wound. With an upward stroke he inflicts a wound some 2 inches wide, which invariably penetrates the wood. As the tool is withdrawn the cortex sometimes breaks out above the cut, exposing the wood, or the wood itself is splintered. The number of cuts made depends on the size and condition of the tree. Eight or more cuts may be made on a tree in one day, or the number may be less. The daily mutilation over a period from June to January eventually results in such injury that the tree must be abandoned. Sometimes tapping is continued overhead, viz, beyond the reach of a man standing on the ground. This is usually done by erecting a platform of poles of varying stages around the tree. By this means the tapping may be carried up for many feet from the base.

The immediate response on the part of the tree to this form of tapping is a vigorous effort to repair the damage. After the cessation of the flow of latex, that which remains in the cut coagulates and for a time affords protection to the cambium and mutilated latex cells against atmospheric influences and infection by spores of fungi and insect attack. Akers, writing of the conditions in the Amazon, is of the opinion "that this residue of latex left in the cut is the salvation of the industry, when the serious injury inflicted on the trees from the constant use of the ax is taken into consideration." While the cut is temporarily sealed by the coagulated latex, the healing mechanism previously described begins the formation of a callus. The outer cortex at the edge of the cut develops a protective layer of wound cork. From the region of the cortical parenchyma and the bast adjoining the cambium a multiplication of cells takes place. These cells continue to develop, usually abnormally, with the result that large irregular projecting callous nodules are formed around the tapping cuts.

The development of callous nodules around the numerous cuts results eventually in such hypertrophy of the surface that profitable tapping is no longer possible. It is the formation of these calluses on a vertical series of cuts that affords one of the causes for giving the trees a fluted appearance (Pl. XXXI, B). If the entire circumference is tapped the tree becomes abnormally enlarged as far up as the cuts have extended. This gives a bottle shape to the base of the tree.

The structure of these callous nodules is very irregular. When they are sectioned numerous cavities are exposed, representing the overlapping of successive layers of wound wood (Pl. XIV, C). In many cases the callus never successfully closes the wound, but continues to develop in an irregular manner. Its wood may become exposed at the edges through the sloughing away of the bark, so that growth ceases in a tangential direction. In such cases the wood of the cut may be permanently exposed (Pl. XIV, C).

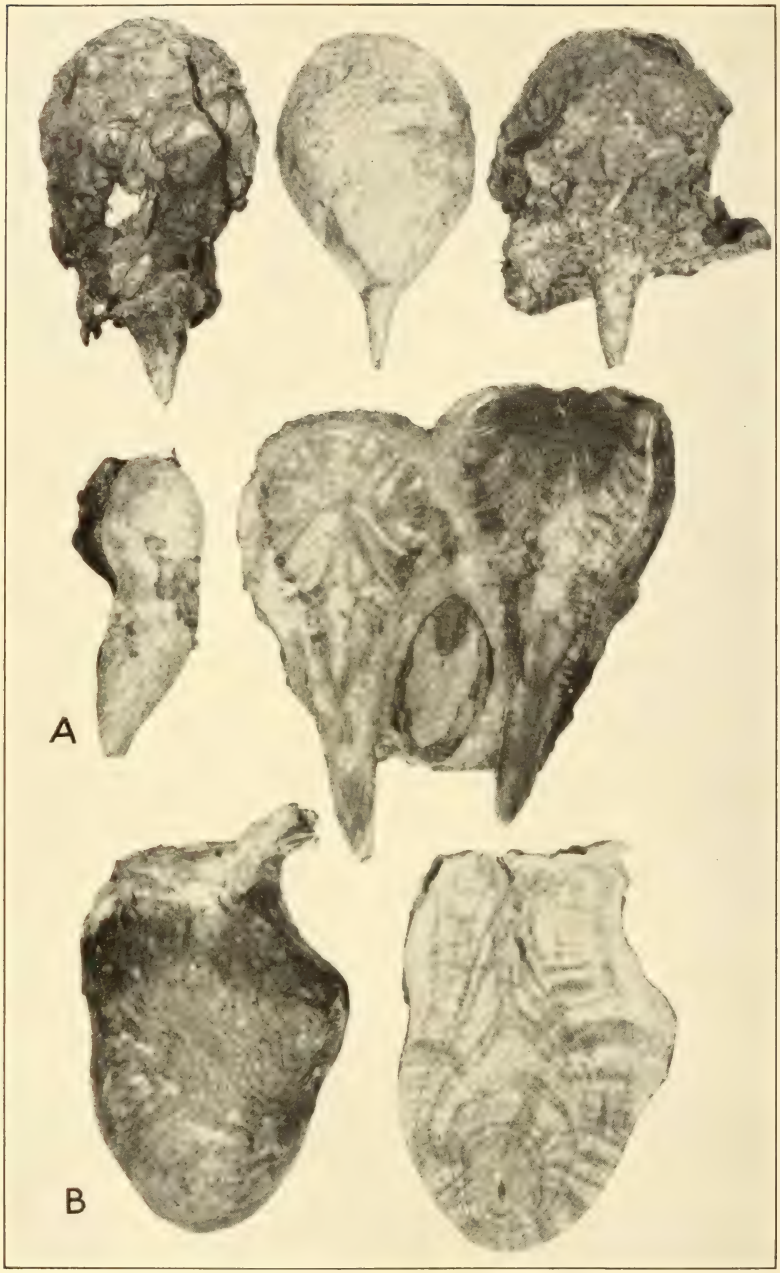
The formation of these callous nodules in combination with those arising from other causes later described results in such a gnarled and irregular surface that the tree is ruined. The condition is apparent in the accompanying illustrations (Pl. XXXI, A and B). Although practically every tree that had been tapped for any length of time had become a mass of woody warts, occasionally a tree which had undergone the same treatment was unusually smooth. The cuts had healed smoothly and evenly with the surface. If there is a probability that there are strains of Hevea that do not respond in the usual way to this form of tapping, they should be considered in selection for propagation purposes.

The overhanging dead bark on the upper side of the cuts may sometimes greatly interfere with the formation of the callus, for the reason that the bark is pushed off with difficulty, and irregular developments result. Ordinarily the occlusion callus should proceed more rapidly from the ends of the cut than from above or below, owing to the narrowness of the cut. This is actually what takes place where a series of cuts has been made one above another. There is a very obvious reason for this, which is explained when the reaction that takes place in the last cut above is described. Here the downward flow of elaborated food substances is uninterrupted by intervening cuts and is conveyed directly to the upper edge of the wound. The reaction is very similar to that when a wire is bound tightly around a tree or when the cortex is removed in a strip around the trunk. In the case in hand the influx of food substances frequently causes the development of flat wood plates that project downward from the upper edge of the cut. These plates are more or less circular in outline and seldom more than an inch in thickness and are slightly appressed to the wound. These plates are attached only at the upper side and consequently do not heal the wound (Pl. XXX, A). Since the bark may be loosened from the wood for an inch or more above the cut, the callus originates at the point where the wood and bark are in union. This results in long thin pendent plates. Callous formations of this type have also been observed in Sapium.

Like many abnormalities, when once initiated the growth of these callous warts is not arrested with the cessation of the original cause. Many old trees which had not been tapped for 20 years or more were still gnarled and knotted, with an abnormal development of the tapped area quite out of proportion to the untapped part of the tree. A return to normal surface conditions, however, would depend on the age of the tree. If tapping is discontinued on young trees soon after they are of tappable size, the wounds, if not infected by fungi, heal very quickly, and all trace of the injury is buried under a new growth. This condition has not only been pointed out by

EFFECTS OF MECHANICAL WOUNDS ON HEVEA

A, Large callus nodules as a result of tapping; B, fluted surface due to excessive tapping and formation of callus nodules



ABNORMAL GROWTHS ON HEVEA

A, Preventitious structures in cortex, showing point of attachment to parent stem; B, adventitious structures from callus at edge of stump. (Nearly natural size)

EXTERNAL RUBBER PADS ON HEVEA

These pads are known as "black scrap," or oxidized rubber, on old tapping wounds. (Nearly natural size)

persons familiar with the previous history of the trees, but the evidence of old wound tissue blackened by oxidation (wound rot), canker, or superficial molds can be observed in cross sections of felled trunks. The complete healing over of the wounds naturally depends upon their number. A few cuts here and there or a few rows properly spaced around the trunk would in time be covered over more rapidly with fewer callous warts than when the entire surface had been hacked up. The latter condition stimulates such surface abnormalities with subsequent changes in the uninjured wood that the tendency of the affected tissues to return to the normal is lost entirely, resulting in continuous hypertrophies.

Whether the cuts are healed over and buried beneath new layers of wood or the abnormalities continue, the zone of dead blackened wood, almost continuous around the entire circumference, introduces an element of weakness in the mechanical strength of the trunk. This is due to the fact that the surface of the wound wood is not anatomically connected with the new wood formed over it. This introduces a line of friction, and the two sides may split or separate, causing the tree to be more easily broken under the stress of high winds. On old dead trunks these concentric zones of wood may be split out like troughs.

In this connection it is interesting to note that Cross, in his report to the Indian Office in 1898, makes mention that in the region of Para he found large trees in a state of decay and that up to a height of 10 or 20 feet from the ground the trunk was one swollen mass of warty protuberances and knots covered with thick scales and flakes of hard dry bark. He then describes the system of tapping and concludes that it is the injury done the wood and not overtapping which lessens the flow of the latex and ultimately causes the death of the tree.

The earliest account of the collection of rubber and its effects on the tree appears to be that of Condamine in 1751. This author presents a picture which may be considered to represent the response of the tree to excessive wounding.

Pruning.—On some of the plantations visited and along roadways where Hevea was planted the trees in some cases had produced lateral branches low down on the stem, and these had been cut off. For the sake of improving the form of the trunk it may be found desirable to prune such living branches. It must be remembered, however, that the removal of large living branches is attended with considerable danger to the health of the tree. Not only is there a retardation of growth due to the loss of the assimilatory surface, but the making of wounds on the trunk may result in serious infections unless the operation is properly performed.

The pruning of large lateral branches should be done by triple sawing. First, at some little distance from the trunk, saw one-third or one-half through the branch from the under side. A few inches beyond on the upper side, saw the branch until it splits to the first cut and falls. The weight of the branch now being removed, the stub may be cut off through the bulge at its base and flush or parallel with the trunk. This method prevents splitting and bruising the lower side of the wound, which often occurs when the branch is cut off from above at one operation.

Pruning should be done when the trees are wintering or when growth is at a standstill. At this time there is less water in the wood and the wound is not so liable to infection. The chief reason for pruning at this season is that antiseptic substances applied to the wound are more readily absorbed. If the surface of the wound is moist, such substances do not penetrate the wood and may later flake off, allowing water and spores of fungi to enter.

The artificial removal of branches that had developed low on the trunk was observed at Para and Manaos. In practically all cases the branches had been cut off several inches from the trunk. The projecting dead stubs were infected with fungi and in two cases with species of considerable economic importance.

It is sufficient to state that the modern practice is to cut off the branch as close to the trunk as possible. Projecting stubs soon die, since they are no longer supplied with food. Infection sets in and may spread to the living tissues of the branch collar. Eventually the stub decays, and the rot advances into the parent stem. The effect is the same as that described for naturally pruned branches, and the same set of fungi is concerned.

Lightning injury.—Lightning injury of Hevea in the Amazon Valley was demonstrated in but few cases. On a small tree about 9 inches in diameter near Riberalta, Bolivia, small black scars were distributed over the main part of the trunk in considerable numbers. On another tree strips of cortex about half an inch wide were separated from the wood. These strips were not continuous, but appeared on different sides of the tree. Some of the topmost branches were dead, but otherwise the health of the tree appeared in no wise affected. These longitudinal wounds were almost closed with a healing callus. The small spot wounds in most cases were completely healed. The dead edges of the cortex extended partially over the renewing callus and when removed exhibited a smoothly healed surface. This was in contrast to the reaction from excessive tapping and is explained by the small extent of the original injury.

The wounds were of a uniform depth and involved from one to two annular rings. The edges of the rings were slightly separated from those beneath and the space plugged by a small secondary callus. Otherwise the process of healing was the same as that in injuries from other causes.

If the tree is struck during the growing season the influence of the shock on its growth is usually expressed by the modification of the cells of the annual ring of the season, so that the continuity of the normal structure of the wood is broken. This makes a possible defect in the wood when the trunk is forced to sustain heavy loads, as in the case of high winds.

FIRE INJURY

On a small plantation near Para trees injured by fire from the burning of grass or other materials along the edge of a clearing were examined.

Although bark is a poor conductor of heat, the normal thinness of the bark of Hevea makes it very susceptible to fire injury. The younger the tree the more serious the injury.

It may not be out of place to discuss briefly the reason why smooth-barked trees are so readily injured by fire.

The medullary rays of the wood cylinder extend through the true cambium into the phloëm of the inner bast layer, terminating in the secondary or cork cambium of the outer cortex. Here, if the tree is young, are located large masses of parenchymatous cells filled with chlorophyll and other delicate structures. The primary rays, those having their origin in the pith, on entering the bast usually spread out in younger trees into triangular areas of delicate parenchymatous tissue which supply the food substances to the cells of the cork cambium. These ray cells are storage reservoirs of food and are chiefly concerned in transporting soluble food substances in a horizontal direction between the cortex and the inner wood cylinder. The food substances used in any part of the tree horizontally or tangentially largely pass through the phloëm, which is in intimate connection, as above noted, with the ray cells. When the close relation between the cortex, the most vital part of the organization of the tree, and the ray cells of the wood and cambium is considered it is appreciated how fire injury to the former may work great injury to the life of the tree.

Protoplasm is killed at a temperature not much over 50° C.; consequently, trees may be very seriously injured when heated but untouched by flames. This type of injury may be difficult to detect until such complications set in as make the hidden wound apparent. An examination of severely heated or scorched trees showed that checks appeared in the cortex along the line of ray cells leading directly to the cambium. If the cortex does not crack open, these concealed fire scars are not detected until attacked by borers or, as sometimes happens, an inward flow of latex causes the formation of rubber pads with a bulging of the dead cortex. In some trees examined the fire had been in direct contact with the cortex, which had fallen away for a distance of a foot or more on the injured parts.

Probably the most immediate result of fire injury from the standpoint of what may be called disease is the appearance in the affected wood of chromogenic fungi. These fungi color the dead wood of the wound, often penetrating well into the more vital portions of the sapwood. It has been determined that the mycelium of wood-staining fungi is only prevented from entering the living sapwood by the high water content of the cells, as determining the presence of the necessary amount of oxygen demanded by the fungus. In all cases where the wood is exposed by wounds of any kind discoloration will take place. This wound rot, as it has been called in early stages of exposure, is not a decay, but a coloring of the wood through oxidation of the cell substances and the action of enzymes. The real decomposition of the woody cell is only brought about by fungi which act directly upon the cell wall. The early discoloration by exposure and staining fungi which do not act upon the wood is only a forerunner of the more serious condition of actual decay. The relation to fungous attack of the fire scars examined at Para was shown by the fact that the exposed wood was discolored by such fungi as Aspergillus, Penicillium, Hypoxylon, Nummularia, and other species. The wood was beginning to decay through the activi-

ties of *Polystictus sanguineus*, *Trametes hydnoides*, and other undeterminable saprophytic wood-destroying species. The edges of the wounds were not healing, being prevented from doing so by species of Diplodia and Corticium.

It is sufficient to state that in cleaning up areas of plantations in the Amazon Valley it will be found desirable to expend as much time and money as the project will permit in burning all forest litter before the trees are set. During the dry season fire may be expected to spread in open plantations if grass and weeds are allowed to grow. Owing to the absence of dead grass and weeds fire does not run in the jungle even during the dry season. This is in marked contrast to the forest conditions in the Temperate Zone. The experiment was tried of setting fire to large termite nests which had fallen to the ground, but aside from the destruction of the nests the fire did not progress farther.

INJURY DUE TO SUDDEN EXPOSURE (SUN SCALD)

At the edge of a small clearing near Para a small Hevea showed effects of sudden exposure to the direct rays of the sun. The tree had grown up under heavy canopy. The bark on the exposed side of the tree had shrunken in patches and was checked through to the wood. In the absence of any evidence of fire abrasion or other injury it appeared clearly a case of sun scald.

It is expected that serious injury from sun scald would result from the sudden exposure of wild Hevea left on plantation areas. The wounds caused would open the tree to infection by fungi and to insect attack.

PROTECTION OF WOUNDS

Holding in mind what has been stated regarding the process by which wounds are healed it is evident that the methods of treatment should be varied to suit the case in hand. Treatment, however, has the one object, viz, to prevent infection by either parasitic or nonparasitic fungi.

BANDAGING

If through accident the bark is separated from the wood without injury to the latter during the period of cambial activity the wound should not be treated with chemical substances. The cambium covering the exposed wood will rapidly form a protective layer if it can be protected against drying, direct sunlight, and the weathering influence of rain. This may be done by placing a bandage of some impervious cloth around the stem, covering the wound. The bandage should be stretched tight; otherwise the cloth may come in contact with the delicate cells of the cambium and cause their disintegration. The application of grafting cloth at the union of stock and scion or the protection by means of screens of peeled surfaces in the treatment of brown-bast are cases in point. After the cambium has developed epidermis the bandage may be removed. The suberized epidermis is not susceptible to infection by the spores of wound fungi, and the conditions favoring germination and penetration of parasitic fungi are greatly lessened.

WOUND MEDICATION

If the wound is of such a nature that the cambium is absent the usual procedure of the application of chemical or other inhibiting substances follows.

In the preceding pages it has been shown that the fungi which enter through wounds are of two major groups.

Nonparasitic fungi act solely upon the dead exposed wood, and by penetrating deeper in the heartwood of the roots and stem they cause a slow decay. This action is hastened by the ingress of rain water, particularly in the roots. Fungi with parasitic tendencies more rapidly penetrate the wound, and after sufficient vegetative vigor has been attained the fungus may attack the viable parts of the tree. To protect wounds from infection by these fungi is the object of wound medication. This is particularly important in Hevea, for the reason that, unlike many other species which produce protective substances from the exposed cells, Hevea wood when exposed checks badly and is readily susceptible to infection.

In general, the fundamentals governing newly made wounds from any cause and their protection may be thus briefly summarized:

All cuts made in pruning branches should be flush and parallel with the surface of the trunk. If the edges of the cut are ragged, they should be smoothed off with a sharp knife, so that the callus may develop uniformly and regularly.

If wounds are large the exposed wood should be treated immediately with a disinfectant solution. Corrosive sublimate of 1 part to 1,000 parts of water is recommended.

After the surface of the wood is dry it should be given a heavy coat of asphaltum. This may be applied hot. It effectually seals the pores of the wood, remains plastic during warm weather, and does not crack off, as do the ordinary lead and oil paints.

Yearly inspections of trees to locate new wounds and to recoat all old wounds that show faulty treatment should be made.

Old wounds that have been overlooked and which have not developed rot may be treated as previously described.

Special methods have been devised for the treatment of wounds made necessary in the control of brown-bast. These consist in shaving down the bark over the affected area to the laticiferous layer and painting it with antiseptic substances or hot tar or stripping off the bark from the wood and under protection allowing the cambium to develop a new cortex.

TREE SURGERY

It may be found desirable after the last thinnings of an estate, with the attendant increased value of individual trees, to treat by so-called tree-surgery methods wounds of long standing in which decay has developed.

A remarkable instance of the successful treatment of a large trunk wound on Hevea was observed at Manaos. The tree had been seriously injured mechanically, and decay had developed. The decayed wood was removed and the cavity filled with cement. At the time of inspection the wound had completely healed, so that its location on the trunk could scarcely be detected. A similar treatment of a large root wound in the Seringal Miry at Manaos was not so successful, as the accompanying illustration shows. (Pl. XXIII, B.)

The types of wounds that may be treated profitably by surgical methods are those in which the decay has not advanced to the point

where the excavation would involve too great an area of the surface of the trunk or the heartwood. The wood of Hevea is not very strong, especially in young trees, and a large excavation would cause the tree to be broken off by the wind, either in the case of cavities at the base of the tree or higher on the trunk. A greater measure of success would attend the operation at the base of the trunk, owing to the greater mechanical strength at that point.

A first requisite in treating wounds by this method is a knowledge of the fungi concerned. Obviously it would be useless to attempt to prevent in this way the spread of the decay caused by a parasitic wood-destroying fungus. The mycelium is usually so far in advance of the visible decay that it is impracticable to judge its extent in the roots and root collar; also at the time the decay becomes apparent the tree may already be doomed. *Polyporus lignosus*, *Poria vincta*, and other parasitic fungi fall in this class. The activities of wood-destroying fungi that attack only the dead wood of wounds or enter the heartwood by this means may be successfully combated but only when the operation is properly performed. The operation will not be a success unless all the diseased wood is removed. The decay will continue behind the filling if all the infected wood is not taken out. After the diseased wood is removed the raw surface should be thoroughly treated with a disinfectant. When the surface is dry it should be painted with asphaltum and the cavity filled. The filling should not extend beyond the cambium. This will permit the callus to form evenly over the surface and hold it in place. If the healing is complete the surface of the trunk will be uniform. In some cases it may be desirable not to fill the cavity after thorough disinfection and application of asphaltum. If the cavity is so made that water will not collect in it, it will soon dry out under such treatment, and decay or reinfection will be prevented. Cavities treated in this way, however, do not have a finished appearance. There is also the loss of tapping surface, since it requires a long period for such cavities to occlude.

PREVENTITIOUS AND ADVENTITIOUS NODULE STRUCTURES

The practice of wounding the tree to collect the latex promotes the formation of other forms of abnormalities which are much less conspicuous than the callous nodules. Before these abnormalities are discussed it is well to consider certain regenerative phenomena which may be intensified by this form of tapping, by injury to the crown by various agents, or that may be a natural response on the part of the tree for self-maintenance.

The normal buds of a young tree may be distinguished according to their position as acropital and axillary, as they are developed at the end of the new shoots or in the axils of the leaves. With regard to their manner and mode of development, they may be distinguished as shoot forming and as dormant or preventitious buds. The first are characterized by the vigorous production of shoots which normally branch and again produce acropital and axillary buds. These shoots usually stand at an acute angle to the parent stem. Although several lateral or axillary buds may be produced, only a limited number develop into shoots. The others remain

dormant or imperfectly developed and are known as preventitious buds, for the reason that they occur on the stem from the beginning. These buds are provided with their own cambium and increase in length only so far as to keep up with the annual increment of the parent stem. They extend their growth beyond only when the parts above are injured. It is these buds which give rise to shoots from the sides of stumps or which replace the branches that have been killed by Dothidella or other agents.

The mutilation of the trunk by excessive tapping, pruning, and defoliation by insects or fungi may also initiate the development of these buds into shoots, the requirement being that they receive an excess of nourishment. Not infrequently these buds through a cessation of growth in their own cambium become disconnected from the wood of the parent stem and by a later concentric disposition of wood give rise to spherical or oval nodules embedded in the cortex (Pl. XXXII, A). They may by exfoliation of the bark be gradually brought to the surface, and since they have no connection in the late stages with the wood of the tree they may be easily detached or may eventually fall with the bark scales. These globular shoots or sphaeroblasts, as they have been called, rarely exceed 2 inches in diameter. On some coniferous trees they may attain a diameter of 9 inches or more. Smaller ones are common on beech and other dicotyledonous trees. These nodules under the influence of various stimuli may develop into shoots. They may occur on the smooth bark at any point on the main stem, but are more common at the root collar and in the region of old leaf scars.

Preventitious buds may be distinguished from cortex nodules by their structure and mode of origin.

Under the influence of certain stimuli bud structures may originate on fully developed parts of the tree, becoming what are known as adventitious buds. If their development is arrested they form elongated structures with concentric arrangement of the wood. They usually originate on the callus of such a wound as may occur at the top of a stump or on tapping wounds and are attached usually by a broad base (Pl. XXXII, B). It is these buds which give rise to coppice on the stump and roots when the tree is cut or killed above ground. In this case they may originate endogenously on the uninjured cortex, or they may develop from the meristematic tissues newly formed at the edge of a wound. New shoots originating from these buds are commonly found on the stems of young trees which have been cut down. On a few of the stumps shoots originating from both preventitious and adventitious bud structures have been observed. Owing to the rapidity with which the exposed wood becomes infected with wood-destroying fungi, Hevea stumps produce very few new shoots. If such shoots attain tapping size the heartwood at the base is liable to become infected from the diseased wood of the parent stump.

Steinmann reports the occurrence of globular aggregations of undeveloped buds on Hevea in Java. He states that such abnormal development may be attributed to the stimulus of an intracellular fungus, the mycelium of which is found principally in the tissues of the pith. It is not stated whether the buds are of primary or secondary origin.

CORTEX NODULES

In addition to the abnormalities formed by the callus around tapping wounds and preventitious and adventitious structures, another nodule formation, which has an entirely different origin, not infrequently occurs in the cortex of badly tapped trees. These are cortex nodules, which are said to be very common on Hevea in the Orient and are associated with trees which have been badly tapped or tapped for a long time, or they may follow brown-bast and other cankers.

Kuyper has reported and figured such nodules on Hevea in Dutch Guiana. Concerning their occurrence on Hevea in the Amazon Valley Akers states that he looked carefully for signs of these nodules, but found no trace of them, in spite of the fact that the cambium is damaged at every stroke of the collector's ax. He considered that Hevea since its introduction in the Orient had undergone a constitutional change favorable to the production of nodules. In his second work, however, he refers to these nodules on old trees and quotes suggestions in explanation of their origin.

It is not unlikely that considerable confusion has resulted from a misinterpretation of the cause and origin of the various types of nodules on Hevea and that what has been considered a nodule in the usual sense is nothing more than a callous formation or a growth arising from new or arrested buds.

Occasionally on old trees which have been badly damaged in tapping, cortex nodules are not uncommon, but care must be used in the diagnosis of certain of the forms. The nodules may be observed in all stages of development. They may appear singly, in clusters, or may take the form of vertical elongated swellings or ridges.

The first indication of these nodules is a slight swelling. If the outer bark is removed a small mass of wood is found embedded in the cortex without connection with the wood of the stem. The nodule increases in size by the multiplication of the cells of its own cambium, which puts down concentric layers of wood until the nodule attains considerable size. Later, with increased growth, the wood of the nodule fuses with that of the trunk, and a permanent protuberance or swelling is formed. Sometimes before the nodules become attached to the wood they may be exfoliated with the dead bark scales, or they may project and be so lightly attached that they may be removed with a slight pressure. If they become attached and at the same time project, the cortex frequently becomes disorganized at the outer surface and an open cuplike cavity is formed (Pl. III, D).

The initial stages of the nodules vary greatly in shape. They may be spherical, elongated, or more or less cylindrical, or they may consist of flat plates which are developed either by the lateral fusion of a number of small spherical nodules (Pl. XXX, B) or by growth in the form of anastomosing wood fibers. The openings in the fibers through which the cambium extends eventually are closed up, leaving slight depressions on the surface of the plate (Pl. XXX, B). The shape of the initial nodule apparently determines the type of burl or swelling produced and does not appreciably change in later development. A single spherical nodule continues its development until it may form a protuberance 1 to 2

inches in size. If several spherical nodules develop near each other their cambium becomes united, the wood of each fuses with that of its neighbor, and a multiple nodule results. Secondary nodules may later appear on the larger ones, so that the entire mass becomes very irregular.

The flat perforated plates are of rare occurrence. However, they are difficult of detection in early stages and may be overlooked. They are most remarkable when separated from the cortex and appear in some cases as little more than a network of woody strands. As new layers of wood are formed the openings are closed, and the structure assumes the nature of a thin plate. This plate is never plane but is marked by indentations, grooves, and circular striations.

These plates while unattached in the cortex are seldom more than a millimeter thick, with a breadth of 2 or 3 inches. They may extend vertically from a few millimeters to several centimeters. The cambium of these plates eventually fuses with that of the main stem. Conical points of wood develop on the inner surface of the plates which eventually fuse with the wood of the main stem. In some cases this fusion continues until the plate is more or less uniformly attached to the main trunk. Ordinarily, however, the plate remains embedded in the cortex or is attached at only a few points. The plates are very rarely developed singly. On badly tapped trees they may occur in groups or be developed parallel to each other, causing the tree to appear secondarily fluted between the callous ridges. The location of these plates may be detected either by the presence of elongated swellings or by a slight roughness of the bark in advanced stages. In a few cases where the fusion with the main trunk did not take place, a layer of dry rubber may form between the two, owing to the fact that the latex in the cortex between the stem and the plate is forced out as the plate develops, and the latex coagulates in situ. The cortex covering such plates is usually rough with longitudinal fissures and contains little or no latex.

Bateson has pointed out that these nodules were formed around old latex vessels whose contents had undergone some kind of chemical change. This alteration of content causes the formation of cambial cells around the affected vessels, and they are soon enveloped by a layer of wood. If a small nodule is sectioned, a small brown speck is discernible in its center, or the discolored tissues may appear as a line half way between the surfaces of the flat plates. If the discolored tissues are microscopically examined, it will be seen that they consist of cortical parenchyma, or more rarely sclerenchyma cells. The surrounding wood elements are more or less regular in shape, but they become less so the nearer the cambium is approached. The concentric structure of the nodules is conspicuous in cross section. Depending upon the number or extent of the affected latex vessels the nodules are spherical or flattened. If the vessels are affected over a large area, the nodule will take the form of the perforated plates, which is merely the modification of the latex system of one year's development. If the character of alteration in the latex system causes a coagulation of the latex in the intercellular spaces, the fact may be detected by finding cortical cells embedded in a ball of dry rubber in the center. Lesions of various kinds in the cortex into which the latex has flowed and has there coagulated, initiating the formation of nodules, are of common occurrence.

The cause for the alteration in the latex system has not been explained. Whether the nodules are initiated from the modification of the latex vessels or from the accumulation of irritating bodies in the cortex the response is the same. The tree makes an effort to cast out the centers of irritation or surround them with protective tissues. Since nodules are rarely formed in the cortex of normal or untapped trees, it would seem that their origin must be traced to certain stimuli set up by injury to the bast and cortex. For this reason the nodules are common on trees that have been subjected to abuse by the tapping ax. Small pealike nodules were found on the renewing bark at Manaos, where the eastern tapping method had been employed (Pl. XXIII, B). The nodules were present on the trees at Para attacked by brown-bast. In this case the nodules developed around disorganized tissues in the thin laticiferous layer immediately adjoining the cambium.

Akers makes the statement that he is convinced that these excrescences in the Malay Peninsula are the result of suppressed bud expansion. He later quotes Huber as holding the same view and as stating also that they may be induced by action of hot sunshine on renewed bark. These views, however, are not applicable in the present instance.

The severe tapping to which the trees in the Amazon Valley are subjected is undoubtedly responsible for the several forms of nodule development described in the foregoing pages. The final result is that the entire surface of the trunk within reach becomes so gnarled and irregular that it is no longer practicable to tap the tree either by the eastern or the local method. The bark over the plates and nodules is usually thin and difficult to tap without further injury to the cambium. It was frequently noted that the latex from the cortex on these nodules was of a peculiar yellowish color, quite unlike that of the normal parts of the tree, and coagulated more rapidly.

Although it is undoubtedy true that the local tapping method is the cause of the excessive development of nodules and induces the various types described, a few cases have been noted where trees tapped at the same time as those producing nodules remained free from nodules of any kind. If there is any probability that certain strains of Hevea do not respond to injury by the production of calluses and nodules, the fact should be considered in the selection of seeds and budwood.

All nodules, regardless of their origin, when not attached to the wood should be removed. This may be done by lateral pressure without injury to the cambium. When attached to the wood by one or more points a slight blow will break them loose. Larger nodules may be cut out, if thought desirable, and the wound smoothed over and painted with antiseptic substances.

ABNORMAL EXUDATIONS OF LATEX

The exudation of latex from the cortex attacked by various fungi has been recorded in preceding pages. Not infrequently latex is found exuding from green fruits and twigs, branches, and trunks without any apparent cause. In the case of the attack by fungi the mechanical injury to the tissues may cause either a flow of latex from

the locally affected area or a flow to the injured tissues from the surrounding parts, with subsequent coagulation in the latex tubes. This is analogous to the pathological effects of fungi which break down the resin system of coniferous trees, resulting in an impregnation of the wood and bark. The exudation of latex without the agency of wounds by fungi and animals is more difficult of explanation. It is not analogous to the dissolution of substances in the cortex of various gum-producing trees, since an entirely different process and a different set of structures are involved. The formation of resin blisters in the parenchymatous cambial tissues of many conifers is probably the nearest approach to the conditions found in Hevea.

Long streaks of black coagulated latex have been observed on the smooth white bark of Hevea. If the point of exit is examined by shaving down the cortex a small discolored spot may be exposed, but the surrounding tissues and the cambium beneath appear to be perfectly healthy. It is possible to conceive of an excessive turgidity of the latex system on young green stems under favorable growing conditions, resulting in a rupture of the epidermis and flow of latex. Short splits in green twigs from which latex has exuded were observed on Hevea and also on Ficus.

It would be difficult to decide just what part insects and birds play among such phenomena. It has been pointed out that latex sometimes exudes from abnormally formed lenticels on young twigs. This may be considered a natural response to a diseased condition.

It is unlikely that latex will flow from the cortex on mature parts of the tree without the intervention of wounds of some kind. The report that Hevea trees in Brazil and Bolivia have been known to burst, causing the formation of large masses of coagulated rubber at the wounds, is probably confused with similar phenomena resulting from lightning wounds or abrasions from falling objects.

Certain undetermined insects were observed to puncture the delicate green epidermis of young fruits, causing black spots and streaks to appear on the surface. Other forms of latex exudations seem to emanate from the activities of the numerous tree cuts.

RUBBER PADS

Sometimes the latex, instead of flowing outwardly, accumulates and coagulates in pockets between the cortex and the wood, forming lenticular pads. These were found around old tapping cuts, on surface roots where the cortex had been bruised from treading, and in old cankers of unknown origin at the base of untapped trees. Pads formed beneath healthy though slightly roughened bark were found in a few cases only (Pl. XIV, B). A blow on the slightly raised areas caused a rebound of the ax and resulted in their discovery. The surface of the wood beneath was discolored, but otherwise the surrounding tissues were healthy. The rubber of all these pads was clear and of good quality.

A very curious pad formation is found on old tapping cuts of old trees in damp situations. It appears that the coagulated latex in these wounds is infested with an insect. Evidently the flow is stimulated after the infestation; otherwise the size of some of these pads, known as black scrap or oxidized rubber, would be difficult to explain. They are frequently found as large as a man's fist and

may be elongated or hemispherical in shape (Pl. XXXIII). Their structure, however, may tend to increase their bulk. Instead of being of solid clear rubber their internal appearance is that of a black rubber sponge, with the exception that the cavities are usually elongated and tend to radiate from the base. These cavities are apparently inhabited by the insect, since cocoons of a brown substance were found in them. The surface of the pads appears to be made up of gelatinous granules resembling the excrement of some insects.

A fungus, *Dendrographium atrum*, was always found growing on the surface of these pads. This species forms short, black, stiff hairlike stalks which consist of bundles of septate hyphæ. On the free ends of the hyphæ multicellular dark-colored conidia are produced in chains. These stalks are frequently so abundant on the pads as to give them the appearance of a fuzzy ball. What relation the fungus has to the structure and formation of the pads is unknown. Various blue-black molds were also present, different from those usually found on crude rubber.

An injurious effect seemed to accompany the development of these pads, in that the cuts supporting them were not healed and were frequently of a cancerous nature, with much discoloration of the surrounding tissues.

CHLOROSIS OF LEAVES

Mention has already been made of a sclerotic condition of Hevea leaves in connection with an indeterminate leaf disease. Chlorosis without fungus association was not uncommon on leaves of young trees growing in dry sandy soil. The yellowing of the leaves was either uniform over the surface or appeared as irregular areas and sometimes bounded by the larger lateral veins.

Chlorosis occurred in two forms. In one the epidermis on the upper side of the leaf only was affected, causing an opaque condition when the leaf is held to the light. In the other the yellow spots were translucent to transmitted light, and they were apparent from both sides of the leaf.

No fungi or insects were found on chlorotic leaves, although the condition could be caused by the latter. The condition sometimes is known to be induced by root-rot and insufficient nourishment, but it was not possible under the circumstances to determine that point.

ABNORMAL GROWTHS AND CONDITIONS

SPIRAL TRUNK

The widely observed spiral, twisted, or screw growth of the surface of trunks so common on conifers and frondose trees in the Temperate Zone was noticed in a small even-surfaced Hevea standing in damp soil on the Rio Solimoes. In this case the phenomenon was quite conspicuous, the spiral line of growth making one complete turn within the space of 2 feet of the longitudinal axis of the trunk. This phenomenon has not been very satisfactorily explained. It is sometimes considered to be the result of the departure of the cambial cells in their line of growth from the vertical, causing the wood to be laid down at an angle to the longitudinal axis of the trunk.

The bark on this tree, though smooth, was thin, about one-fourth inch, and the flow of latex was poor.

ABNORMAL STEMS AND ROOTS OF SEEDLINGS

In dense stands of reproduction it not infrequently happens that seedlings assume abnormal shapes. This may take the form of a fasciation or broadening of the stem, resulting in curled hornlike extensions with apical abortive leaf development, or a rosette arrangement of the leaves may develop. Out of several hundred seedlings examined four such monstrosities were discovered.

Seeds of Hevea as they are scattered over the forest floor come to rest and germinate in various positions. When not very deeply submerged or scarcely at all, as is usually the case, and with the micropyle often pointing upward, the radicle may develop for some distance before it enters the soil. This may result in an abortive or twisted radicle, with excessive lateral root development. The shoots developing from seeds lying in different positions, being retarded by the slow development of the radicle, curve about and sometimes form complete loops before becoming vertical. The stems of a large percentage of the seedlings examined had taken a sharp right-angle turn (Pl. VII, C). This was due apparently in some cases to the development of the shoot beneath the seed and its subsequent upward turn, or it may have resulted from the horizontal growth of the radicle before entering the soil.

Seedlings which had apparently suffered some injury to the original shoot, with the development of two lateral stems, were of common occurrence (Pl. VII, C). Straight stems in line with the radicle were common only in the cases where the seeds had become thoroughly embedded and in a horizontal position. This would be the method of planting in nursery practice.

ABNORMAL LENTICELS

On internodes of twigs 1 or 2 years old which had been repeatedly defoliated by *Dothidella ulei*, it was frequently observed that the lenticels had developed unusually large intercellular spaces. The spaces were filled with a powdery mass of cork cells and often in such abundance as to cause longitudinal splits in the epidermis. This condition was not observed on normal or uninfected trees and is apparently a reaction from the continued loss of the foliar surface and hastens the drying up of the twig and attack by secondary fungi. Latex was found to exude in some cases from these lenticels.

VARIATIONS IN BARK THICKNESS

The bark of trees with uniform or symmetrical development of crown and brace roots as a rule was of a uniform thickness. Individuals with strong lateral branches of roots usually developed a thicker and more laticiferous bark on the side more abundantly supplied with food.

CORK NODULES ON GREEN STEMS

Up to a certain age the outer bark of Hevea is chlorophyllaceous. Two small trees were observed to have begun the development of

cork tissue in small isolated patches on different parts of the stem. The cork development took the form of small tubercles 2 to 4 millimeters in diameter and projected about 5 millimeters above the surrounding green bark. These tubercles could be rubbed off with the hand, leaving small brown depressions. Since the formation of the outer cork layer is uniform over the entire surface of the stem this phenomenon was noticeable.

ABNORMAL PODS AND SEEDS

The surface of Hevea pods is normally smooth. Occasionally pods with the surface raised in wartlike tubercles or ridges were observed. In all such pods the seeds were normal.

Seeds with calluslike ridges or outgrowths at the pointed ends were observed in a few instances.

SOIL AND MOISTURE RELATIONS

The direct influence of the different kinds and conditions of soils in the Amazon Valley on the vigor and disposition to disease in Hevea was observed in but few cases. In general, red or yellow subsoils predominate over the entire region. These are covered either with a rich forest mold or alluvial deposits. In some regions these subsoils are covered with a layer of sand with little or no topsoil. The sandy soils occur frequently in the lower Amazon region, and when above inundations they become very hard and dry. The effect on Hevea is a stagnation of growth and a general loss in vigor. The taproot in some cases may not be able to penetrate the harder strata beneath, and this results in early decay. This condition was observed where trees had been blown over by the wind. A short distance away from the banks of the streams in some regions the ground is low and swampy. The soil is usually a light-colored clay, without much forest mold or alluvial deposits. The few Heveas observed growing in such situations were of low vigor and showed evidences of root decay.

The finest rubber is found wherever the yellow or red clay soils predominate on the higher levels where they are porous and well drained and have a good cover of humus. Little disease of any kind was observed in such locations. Such sites would no doubt afford the best opportunity for growing rubber.

A few Heveas were found growing in a permanently wet or water-covered swamp, notably on the flats between the high bluffs and the banks of the Rio Solimoes. Such trees were of considerable height but of small diameter. There was root-rot, and the leaves were much attacked by fungi.

The floods transport and deposit the seeds of Hevea on all types of soils in the low lands. The migration of the tree from the high lands of the upper drainage to the lower Amazon was no doubt brought about in this manner. Observations show that on land where the roots of Hevea are permanently below the water level or when established in poor, compact, undrained soils the trees do not attain as great a girth and state of vigor as when growing on the higher levels.

An especially interesting case of this kind was observed on the Rio Marmore. In a low boglike area some Heveas had succeeded in establishing themselves in the white, soggy, poorly drained soil, very evidently underlain by a hard impenetrable layer. The trees showed a stag-headed condition. In some cases they were leaning or were blown over, and the taproots were found to be decayed. The nature of the decomposition of the taproots left little room for doubt that the sickly appearance and reduced vigor of the trees were directly referable to the condition of the soil. It is not generally believed that an actual decomposition of wood results from a purely chemical action of the organic or inorganic acids of the soil, although this may be possible under very specific conditions of stagnation and insufficient aeration. The fermentative action of bacteria, together with the presence of higher fungi, made more active by the constant moisture conditions, no doubt was largely responsible for this type of root-rot.

In wet soils underlain by an impervious stratum of hard clay Hevea may be expected to fall under the influence of wind when left unprotected. For this reason any scheme for thinning out the jungle on areas where Hevea is abundant should be based on a consideration of soil conditions. The hardpan does not admit of the penetration of the taproot to any depth, and it also retains the moisture comparatively near the surface. Under such conditions the surface roots of Hevea have been observed to spread great distances, scarcely buried beneath the surface soil. This may be interpreted as both a moisture and an oxygen relation.

Petch has found that the roots of Hevea except in certain well-known cases will not live permanently under water. The early conception was that Hevea was a species of swampy soils. It is interesting to read the recommendations by Cross and others for planting the tree on wet soils in the East. This at first was practiced, but with disastrous results. Petch reports that when Hevea is grown in swampy soil, where the water table lies near the surface, the taproot does not grow below the water level, or, if it does, it soon decays. In some cases such trees had to be propped up to keep them from falling over. This is exactly the condition noted in one or two places in the Amazon Valley.

In a territory so vast as that of the Amazon drainage, where there is unlimited opportunity for selecting sites admirably suited for growing rubber, there should be no excuse for failure to recognize these facts.

PREPARED RUBBER

MOLDS

The prepared rubber assembled at the stations along the rivers and awaiting shipment to Manaos or Para not infrequently develops various molds. Between the periods of collecting the latex the soft plastic balls of rubber that are in the making are placed in the sun to dry. The surface may become infected with the spores of these molds, which are inclosed in the ball when the next layer is applied. Consequently, when the balls are opened up for inspection or for more thorough drying in the warerooms at Manaos and Para, the

molds in some cases may be developed vigorously. The freshly cut surfaces of these balls were frequently observed to be yellow, green, or black, depending upon the particular mold present.

Latex coagulated with formalin and kept for some time in a closed box during certain yield experiments became thickly coated with molds. The large proportion of moisture in the balls as they are made up in the forest is responsible for the vigorous development of these molds. A microscopical examination in the field showed that these organisms are the same as those that may be expected to occur on all organic substances in tropical countries during wet weather. The forms most commonly observed were species of Penicillium, Aspergillus, Oidium, Trichoderma, Sterigmatocystis, and other indeterminable Hyphomycetes.

If the crude rubber is manufactured into sheets or crêpe in the Tropics the spores of these molds may survive the washing and milling process even by the most recent methods and cause molds that appear after packing for shipment. Considerable trouble is experienced with mold on crêpe or sheet rubber in transit to the manufacturer. Ribbed smoked sheets from the Orient sent in for examination from New York were badly molded while in transit.

The methods employed for preventing moldiness on rubber have apparently not been attended with complete success. The application of disinfectants both to the latex and to rubber after manufacture have been tried.

A commercial preparation known as chinosol has been used as a disinfectant when added to the latex in the proportion of 0.1 gram per liter of latex to prevent spottedness in dry crêpe or by soaking the freshly rolled sheets in a dilute solution (0.05 per cent) to prevent rustiness. This preparation, however, when used as a disinfectant was not found to prevent molds on sheet latex.

Some recent research on the subject has been made by Stevens. The addition of 1.8 grams of sodium silicofluoride to 3,000 cubic centimeters of latex and 3 grams to 3,000 cubic centimeters of latex was used to prevent mold on smoked sheets. Acetic acid in the proportion of 1 to 1,200 was used for coagulation. Stevens later verified his former results, finding that sodium silicofluoride in the proportion of 1.8 grams to 3,000 cubic centimeters of latex prevents all but the slightest traces of mold on sheet rubber during transport. Edwards experimented with the same chemical and verified Stevens's results. Soaking the sheets before smoking produced resistance to mold in a high degree.

The chief factor promoting the growth of mold is the presence of moisture. Thorough drying of both sheets and containers will reduce the extent of molds or prevent their growth altogether if the drying is thorough enough. At Para crêpe, which ordinarily either does not mold at all, owing to its more thorough washing, or is attacked to a much less extent than sheets, was found to develop mold if rolled up when moist or if placed in a box of unseasoned boards.

Thorough drying before packing to insure the evaporation of all moisture in the usual indentations on sheet and crêpe rubber, the use of bone-dry containers, and storage in dry holds while en route are good practices. *Aspergillus repens* will grow on substrata having a

very low moisture content; hence it is this organism that is likely to develop on substances that are apparently dry.

The quality of rubber is apparently unaffected by the growth of superficial molds.

DISCOLORATIONS

Before the modern method of drying rubber by controlled temperature was introduced various discolorations appeared on the product. These defects have become of less importance with the introduction of artificially heated and properly ventilated drying rooms. The organisms and the discolorations with which they are associated are here listed.

List of organisms causing discolorations found on prepared rubber

Actinomyces elastica Söhngen and Fol. Developed on especially prepared rubber sheets after inoculation with garden soil.

A. fuscus Söhngen and Fol. Developed as above.

Aspergillus sp. Associated with transparent spots on unsmoked sheet or biscuit rubber.

A. repens De By. Developed on crêpe rubber at Para.

Bacillus prodigiosus. Recorded by Brooks as causing red spots on biscuit, sheet, crêpe, and scrap rubber.

Chromosporium crustaceum Sharp. Considered by Sharples to cause black spots on sheet and crêpe rubber.

Diplodia theobromae (Pat.) Nowell. Said by Bancroft to produce dark-blue spots on crêpe rubber, infection being caused by the use of green jungle poles in the drying houses. Sharples was unable to verify the findings of Bancroft.

Eurotium candidum Speg. Considered by Sharples to have some relation with circular white opaque spots on sheet rubber coagulated with acetic acid.

Fusarium sp. Said by Sharples to cause a violet flush on sheet rubber.

Monascus heterosporus Schroet. Obtained by Bancroft from red spots. He also reproduced the spots by inoculating freshly coagulated biscuit rubber with the spores.

Mycogone sp. Obtained by Bancroft from a red-flush discoloration of sheet rubber.

Oidium sp. Developed on smoked rubber sheets in the Orient and in the Amazon region.

Penicillium maculans Sharp. Considered by Sharples to cause a broad yellow diffused coloration of sheets or an orange spot in crêpe rubber.

P. petchii Sartory and Bainier. Developed on scrap rubber in the laboratory at Peradeniya.

Physarella mirabilis Petch. Developed on rubber in the laboratory at Ceylon.

Protococcus nivalis. Spotting reported by Bancroft.

Rust. Applied to a thin brown film which forms on smoked sheet rubber as it dries, variously interpreted to be due to the exudation of serum or protein material or to the decomposition of this material by a microorganism.

Spondylocladium maculans Bancroft. Obtained by the author of the species from dark-green or almost black or yellowish red spots on crêpe rubber.

Sterigmatocystis sp. Developed on ball rubber; Amazon region.

Syncephalis sp. Red marking; Ceylon.

Torula heveanensis. Rustiness of rubber, reported by Groennewege.

Trichoderma koningi Oud. Isolated by Sharples from dense blue-black spots having a violet margin on crêpe rubber.

FUNGI REPORTED ON HEVEA

The following will be found to be a useful check list of the fungi reported on Hevea. Technical descriptions and mycological notes

are given for the most important species. Unless otherwise indicated the host is understood to be *Hevea brasiliensis*.

Allescheriella urcdinoides P. Henn. On leaves *and decaying stems, Rio Jurua*, Bom Fim, Brazil.
Alternaria castilloae Zimm. Dutch East Indies.
Ampullaria succinea Petch. On fruit, Ceylon.
Apiosporium atrum Mass. On dead branches, Malay Peninsula.
Aposphaeria hereae Petch. Pycnidia globose with a conical ostiolum, or oval, black, minutely rugose, 0.15 to 0.2 millimeter in diameter, clustered in cracks in the cortex arising from a thin, immersed, black stroma; well stout, cellular; basidia simple, short, up to 12 μ long; spores narrow-oval, hyaline, continuous, thin walled, 8 to 12 by 3 to 4 μ, a few broadly oval 6 by 4 μ (Petch). On dead bark, Ceylon.
A. ulei Henn. Pycnidial stage of *Dothidella ulei* P. Henn.
Arcyria denudata (L.) Sheldon. On dead stump, Malay Peninsula.
Armillaria mellea (Vahl.) Fr. Decay of roots, Uganda.
Aschersonia aleyrodis Webber. Stroma hypophyllous, pinkish buff or cream-colored, surrounded by thin grayish white mycelia; perithecia at first superficial, later immersed ostiolate; spores fusiform, hyaline, mucilaginous, sometimes 3 to 4 guttulate, 9.4 to 14.1 μ long by 0.94 to 1.88 μ wide, abundant, forming reddish masses. On leaves Amazon Valley.
A. sp. Petch (1921), on scale insects on leaves, Ceylon.
Ascochyta hereae Petch. Affected areas marginal, white, or brownish white with a narrow red-brown border. Pycnidia immersed, ostiolate, not beaked, black, 60 to 100 μ in diameter; spores oblong, hyaline, 1-septate, ends obtuse, 9 to 12 by 5 μ (Petch). On leaves, Ceylon.
A. sp. Spots, irregular or round, scattered, grayish white in the center when mature, with blackish green border thinning out to the normal color of the leaf, green color permanent after death of leaf, reddish brown to blackish on the lower side of the leaf; pycnidia submerged on the upper side of the leaf, spherical or somewhat flattened, membranous, purplish black or grayish externally when old, ostiolate, 50 to 100 μ in diameter, with very stout beak 16 μ long; spores oblong-elliptic, obtuse, or acute, depending on age, hyaline, septate, constricted at the septum slightly or not at all, cells often unequal in size and easily separating, 10 to 18 by 4.5 to 6.75 μ. Differs from *Ascochyta hereae* Petch in possessing a short beak and in its effect on host. Spore measurements as given by Petch are somewhat smaller.
Aspergillus flavus Link. Forming little tufts of yellow heads on suppressed leaves, Amazon region.
A. famigatus Fres. On living leaves and stems in contact with dead vegetable matter, Amazon region.
A. fuscus Bainier. On living suppressed leaves and petioles, Amazon region.
A. nidulans (Niger) Van Tiegh. On living leaves in contact with decaying vegetable matter, Amazon region.
A. niger Van Tiegh. On suppressed living leaves in dense shade, Amazon region.
A. repens De By. On living suppressed leaves, petioles, and inflorescence spikes, Amazon region.
A. sp. On fruits parasitized by Phytophthora, Amazon region.
A. sp. Bancroft (1911), saprophytic on tapping surfaces, Malay Peninsula.
Asterina tenuissima (Petch) Theiss=*Chaetopeltopsis tenuissima* Petch. On green stems and fruits, Ceylon, Malay Peninsula.
Auerswaldia examinans (Mont. and Berk.) Sacc. On leaves and stems, Philippine Islands.
Auricularia brasiliensis Fr. On dead stems and branches, Malay Peninsula.
A. polytricha Mont. On dead stems and branches, Philippine Islands, Ceylon, Brazil.
A. tremellosa Fr. On dead Hevea, Ceylon.
Botryodiplodia elastica Petch=*Diplodia theobromae* (Pat.) Nowell.
B. theobromae Pat.=*Diplodia theobromae* (Pat.) Nowell.
Botrytis sp. Parasitic on *Dothidella ulei* and *Catacauma huberi*, Amazon region.
Calosphaeria sulcata Petch. On dead branches, Ceylon.
Calvatia gardneri B. and Br. On dead Hevea, Ceylon.
Camillea sagracana (Mont.) B. and C. On dead branches, Amazon Valley.

C. poculiformis (Kunze) Lloyd. On dead wood around old tapping wounds of living trees, Amazon Valley.

Capnodium brasiliense Puttem. Mycelium crustaceous, broadly effused, hyphæ greenish black, cells unequal, constricted at septum to 5 to 12 μ, hyphal cells forming chains of almost cubical conidia 4 to 6 μ in diameter (Torula stage) : hyphal cells dividing in three dimensions, forming compact masses of conidia 3 to 5 μ in diameter (Coniothecium stage) ; hyphal cells bearing laterally on short stocks, elongated, narrow, greenish brown, somewhat clavate, 5 to 6 septate, conidia 40 to 60 by 3 to 4 μ (Brachysporium stage) : hyphal cells bearing 4-celled or 5-celled branches radially attached to form a stellate conidium (Triposporium stage). Pycnidia elongate, fusiform, or cylindric, simple, sometimes forked, rarely branched, open at the top, 250 μ long by 40 μ broad : spores elliptical, hyaline, 5 by 2 μ in diameter. Perithecia small, stalked, cylindrical, or fusiform, open at the top, and fringed with small teeth 30 to 60 μ in diameter ; asci variable, fusiform to clavate, 4 to 8 spored, 30 to 35 by 11 to 26 μ in diameter ; spores hyaline, then dark smoky green, 3-septate, second cell from top broader than the rest, 13 to 16 by 5 μ in diameter. On Hevea and coffee, Amazon Valley.

C. javanicum Cke. On insects on leaves, Dutch East Indies.

C. lanosum. On leaves, Amazon Valley, Orient.

Catacauma huberi (P. Henn.) Theiss. and Syd. Stroma subepidermal, forming in yellowish or yellowish brown areas, appearing first on the death of the hypophyll as a thin brownish or blackish crust covering or encircling the discolored area, later anastomosing in radiating or concentric broad black bands or becoming confluent to form a conspicuous black stromatic layer from 20 to 60 μ in thickness ; hyphæ of stroma 6.9 to 10 μ broad, parallel to each other and at right angles to the surface ; perithecia single or crowded in large masses, ostiola conspicuous ; asci clavate, 8-spored, 60 to 95 by 15 to 22 μ ; spores biseriate or obliquely uniseriate in lower part of ascus, ovoid to elliptical, hyaline, 15 to 20 by 8 to 11 μ ; conidia hyaline, unicellular elongate, 12 by 3 μ. On leaves of *Hevea brasiliensis, H. discolor* (Ule, Herb. Brasiliensis No. 3048), *H. pauciflora* (Ule, Mycoth. Brasiliensis No. 73) *H. nivea*, and on other species noted in the herbarium at Para. This fungus was first named and described by Hennings in 1900 from material collected in 1898 by Huber (No. 16) near Para on young *H. brasiliensis*. In 1904 Hennings again recorded it from Para as parasitic on leaves of *Hevea* sp., with an illustration and description. In the same year he reported collections by Ule on *H. brasiliensis* from Manaos (July, 1900, and Jan., 1901), at Santa Clara on the Rio Jurua (Oct., 1900), and at Sao Joaquim (Jan., 1902) and Jurua Miri (June, 1901) on the Rio Negro in Amazonas. Petch contributed an article on the fungus in 1908. In the same year Rehm, from material collected by Baker on *H. brasiliensis* at Para, described and issued the fungus in his exsiccatum. Cook compiled the existing information on the fungus in 1913. Vincens in 1915 described and illustrated the fungus in considerable detail. In 1915 Theissen and Sydow placed the species in their new genus Catacauma, established in 1914 on *Dothidia exanthematica* Lev. (in herb.). The material examined by these authors was Ule, Mycoth. Brasiliensis No. 73 on *H. pauciflora* collected at Manaos in 1901 ; Rehm, Asc. No. 1786 on *H. brasiliensis* collected by Baker in 1908, and on *H. nivea*. The species forms a true stroma, and for this reason it is separated from Phyllachora, which in the case of the true species including the type of the genus does not have a stroma. A marginal conidial stroma is present, but in many of the Dothideaceæ such conidial stages have been entirely lost, at least to all appearances.

Cephalosporium lecanii. Parasitic on scale insects on green stems and leaves, Ceylon and Amazon region.

C. sp. Found in moldy rot of tapped surfaces, Malay Peninsula.

Ceratosporium productum Petch. On dead branches, Ceylon.

Cercospora heveæ Vincens. Parasitic on leaves, Brazil. Conidiophores irregular, geniculate, clustered on small reddish spots, 20 to 25 μ high, 3 to 5 μ in diameter ; conidia oval or fusiform, 2 to 5 septate, 25 to 50 μ long, 3 to 5 μ in diameter, on leaves. Vincens found it in association with *Catacauma huberi*.

C. sp. On leaves, Malay Archipelago.
Cercosporella sp. Parasitic on leaves, Ceylon.
Chaetodiplodia grisea Petch=*Diplodia theobromae* (Pat.) Nowell.
Chaetopeltopsis tenuissima (Petch) Theiss. On shoots and leaves, Ceylon.
Chaetosphaeria hystricula B. and Br.=Fracchiaea.
Ciliospora gelatinosa Zimm. On bark, Ceylon.
Cladoderris dendritica Pers. On dead branches, Philippine Islands.
Cladosporium herbarum Link. Mycelium forming numerous small greenish black tufts over surface of leaf, appearing velvety; conidia produced on tufts of erect greenish brown, septate, bent or kneed conidiophores in branched chains, globose, oval, or cylindrical, brown when mature, continuous or 1 to 3 septate, 5 to 15 by 4 to 10 μ, Amazon region.
C. sp. Saprophytic on leaves, Ceylon; on tapped surfaces, Malay Archipelago.
Colletotrichum elastica Kds. See *C. ficus.*
C. ficus Kds. Said to be identical with *Glocosporium elastica* Cke. and Mass. *Neozimmermannia elastica* Kds., and *Glomerella cingulata* (Stonem.) S. and V. S.
C. hevae Petch. Acervuli black, scattered, epiphyllous, 0.1 to 0.25 millimeter in diameter, setæ obtuse, 1 to 2 septate, up to 90 μ long; spores oblong with rounded ends, hyaline, granular, 18 to 24 by 7.5 to 8 μ; basidia 20 to 30 by 6 to 7 μ, thickened upwards (Petch.). On leaves, Ceylon, Brazil, Malay Peninsula.
C. sp. Parasitic on leaves, Java, Malay Archipelago, Cochin China, Uganda,
Coniothyrium sp. On whitish gray spots on the leaves progressing from the tips, occupying almost the entire leaf, and bounded by a purple zone. Diseased area beneath is reddish brown; pycnidia dark colored, epiphyllous, scattered, submerged, spherical or lenticular, ostiolate, deciduous, 50 to 70 μ in diameter, 15 μ high; spores elongate, ellipsoid to cylindric, hyaline when young, olivaceous when mature, with a single conspicuous oil globule, average (50) 4.6 by 2.1 μ; Amazon region.
C. sp. Canker, Ceylon, Uganda.
Corticium calceum Fr. Mistaken determination for *C. salmonicolor;* Malay Peninsula.
C. javanicum (P. Henn.) Sacc. and Syd. Name changed (1902) for *Aleurodiscus javanicus* P. Henn.
C. javanicum Zimm. (1901)=*C. salmonicolor* B. and Br.
C. lilacino-fuscum B. and C. Mistaken determination by Massee of material from Dominica for *C. salmonicolor.*
C. portentosum B. and C. On dead stumps and roots, Amazon region.
C. salmonicolor B. and Br. (1873). Mycelium: Early stage creeping over the substratum, either as fine white threads or forming thin silky silver-white sheets; next stage appearing usually in lenticels or cracks in the bark as small white or pink sterile nodules; Corticium stage forming thin fertile effused rose-pink or ochraceous incrustations; surface pulverulent, finely cracked by right-angle lines; basidia clavate, 4-spored; spores pyriform, hyaline, apiculate, 9 to 12 by 6 to 7 μ; Necator stage appearing alone or with the Corticium stage as spherical orange-red pustules, later breaking up to form irregular ovoid or spherical hyaline spores, red in mass, 6.5 to 21.5 by 8.75 to 35 μ. On Hevea and numerous other plants throughout the Tropics; reported from Porto Rico, Trinidad, Dominica, St. Lucia, Brazil, Java, India, Ceylon, Malay Archipelago, Borneo, Sumatra, West Africa, Philippine Islands, Indo China.
C. zimmermani Sacc. and Syd. (1902)=*C. salmonicolor.*
C. sp. On branches, Brazil, Indo China, Malay Archipelago.
Cryptosporium sp. Acervuli superficial, scattered or gregarious, black, spherical or slightly flattened; spores olivaceous, elongated fusiform, slightly curved, 3 to 4 septate, 2.4 by 27.3 μ. On fusiform swellings at the end of inflorescence shoots.
Cryptoralsa microspora Sacc. On decayed branches, Malay Archipelago.
Cyphella hevae Mass. Thread-blight, Malay Archipelago.
C. sp. On branches affected by die-back, Malay Archipelago; on seedlings, Cochin China.
Cytosporella discoidea Petch. On dead twigs, Ceylon.
Daedalea sp. Heart-rot, Malay Archipelago.
Daldinia concentrica Ces. and De Not. On wounded parts and on dead trunks, Malay Archipelago, Brazil, Ceylon.
D. concentrica Ces. var. *eschoizii* Ehrenb. On dead wood, Malay Peninsula.

Dendrographium atrum Mass. Common on rubber excrescences around old tapping wounds, Amazon region.

Diaporthe heveae Petch. On branches, Ceylon.

Diatrype chlorosarca B. and Br. On dead branches, Ceylon.

Didymella oligospora Sacc. On dead branches, Malay Archipelago.

Dimerosporium heveae Charles, n. sp. Perithecia superficial, bone brown, gregarious or confluent, subglobose, hypophyllous, 70 to 10 μ; asci cylindric-clavate, 48 to 52 μ; spores biseriate, elongate-elliptical, 1-septate, 11 to 12.8 by 2.5 to 3 μ. Type in Pathological Collections (No. 72530), U. S. Department of Agriculture. Parasitic on the stroma of *Catacauma huberi* (P. Henn.) Theiss. and Syd. Amazon region. This species suggests *Dimerosporium manihotis* P. Henn., syn. *Parodiopsis? manihotis* (P. Henn.) Arnaud. (G. Arnaud. Étude sur les Champignons Parasites. Ann. d. Epiphytes VII, p. 72. 1921.) Arnaud states that the ascospores in the material studied by him were not mature, but according to Hennings the spores of this species measure 9 to 13 by 3 to 3.5 μ. The material in the present study was very abundant, but it also appeared immature, whether due entirely to age or the fact of its being parasitized can not be definitely determined at this time.

Diplodia cacaoicola P. Henn.=*D. theobromae* (Pat.) Nowell.

D. rapax Mass.=*D. theobromae* (Pat.) Nowell.

D. theobromae (Pat.) Nowell. Pycnidia small, submerged, scattered or aggregated in a smooth stroma or on a stroma covered with brown mycelium, erumpent, carbonous, black, usually ostiolate, papillate lenticular, or flask shaped; conidia ellipsoid to ovate, rounded at both ends, uniseptate when mature, not constricted, fuliginous, or blackish brown, average (50) 24 to 30 by 13 to 16 μ; paraphyses abundant, filiform, average 60 μ long. The fungus was first described by Patouillard in 1892 under the name *Botryodiplodia theobromae*. Following this it has appeared under the following names: *Macrophoma resita* Prill. and Del. (1894), *Diplodia cacaoicola* Henn. (1895), *Lasiodiplodia nigra* App. and Laub. (1906), *Botryodiplodia elastica* Petch (1906), *Chaetodiplodia grisea* Petch (1906), *Lasiodiplodia theobromae* Griff. and Maub. (1909), *Diplodia rapax* Mass. (1910). Bancroft in 1910 described what he considered the ascigerous stage under the name *Thyridaria tarda*. From cacao stems infected with Diplodia he forced the production of an ascigerous fungus in damp chamber. The life history of the ascospores thus obtained was not followed up; hence the assumption that *T. tarda* represents the ascospore stage of *Diplodia theobromae* was not demonstrated.

D. zebrina Petch. On dead fruits, Ceylon.

Diplopeltis zimmermanii P. Henn. On leaves, East Indies.

Discosia sp. On dead fruits, Amazon region.

Dothidella ulei P. Henn. Stromata erumpent, superficial, cæspitose or aggregate, stromatic, round or oval, black, rugulose, amphigenous 0.2 to 3 millimeters in diameter, on whitish or brownish spots; perithecia few or many, ovoid, loosely or firmly united; asci numerous, clavate, rather obtuse at the ends, 8-spored, 50 to 85 μ long, 10 to 17 μ broad; spores oblong-clavate, hyaline, 1-septate, arranged irregularly in two rows, 13 to 20 μ long, 4 to 5 μ broad, paraphyses present. Pycnidia (*Aposphaeria ulei* P. Henn.) small, black, spherical or ovoid, erumpent, at first submerged, later appearing superficial, single or aggregated, papillate, ostiolate, about 125 to 158 μ in diameter; spores long-cylindric or fusoid, hyaline, straight to somewhat curved, 2 to 3 guttulate, 6 to 10 by 0.8 to 1 μ. Conidia (*Fusicladium macrosporum* Kuyper; *Passalora heveae* Mass.) appearing on translucent olivaceous spots on both sides of the leaf, spots later becoming gray to grayish black or blackish green, at first 3 to 10 millimeters in diameter, later covering the entire leaf with confluent multiseptate hyphæ forming a pseudostroma in late stages; conidiophores erumpent, unicellular or uniseptate, subglobose at the base, brown, sometimes sinuous, 40 to 70 μ high, 4 to 7 μ in diameter; spores ellipsoid, acrogenous, ends obtuse or obclavate-pyriform, irregular, dark brown, unicellular, finally uniseptate, 30 to 55 by 8 to 12 μ. On *Hevea brasiliensis* and other species of Hevea, American Tropics.

Erionema aureum Penzig. On dead log, Ceylon.

Eurotium sp. In cavities in old tapping burls and on fruits parasitized by Phytophthora, Amazon region.

Eutype caulivora Mass.=*Nummularia pithodes* B. and Br. and probably=*N. anthracodes.*

E. comosa Speg. On dead branches and old tapping wounds of living trees, Amazon Valley.

E. crumpens Mass. On stumps that had failed to sprout, Gold Coast.

E. gigaspora Mass. On dead wood, Trinidad.

E. ludibunda Sacc. var. *heveana* Sacc. On dead branches, Malay Peninsula, Amazon Valley.

E. noackii (Rehm) Shear and Diehl, comb. nov.=*Peroneutypella noackii* Rehm. On dead stumps, Amazon region.

Eutypella heveae Yates. On dead branches, Philippine Islands.

Favolus spathulatus (Jungh.). On dead branches and stems, Malay Peninsula.

F. tener Lev. On dead branches, Philippine Islands.

Fomes hornodermus Mont. Fructification very hard and heavy; surface covered with a hard, horny brown or black crust; pore tissues whitish; context whitish, becoming dark colored next the crust; pores minute; spores ellipsoid, hyaline, 7 to 9 by 3.5 to 4.5 μ. On Hevea roots, Amazon region.

F. inflexibilis Berk. On dead trunk, Amazon region.

F. lamaoensis Murr. Pileus hard, woody, persisting, sessile, thin, imbricate, applanate, 2 to 5 by 2 to 6 by 0.3 to 0.8 centimeters; surface zonate, slightly sulcate, horny incrusted, reddish brown to dark brown; margin usually thick, brown, entire; context 3 to 6 millimeters, thick yellowish brown; pores unstratified, 2 to 6 millimeters long, 5 to 6 per millimeter, whitish, stuffed when old; pore mouths circular, regular dull brown or smoke colored; edges even; dissepiments thin, dark or fuscous brown; dissepiment context much darker than the pileus context; spores ellipsoid, hyaline, 7 by 5 μ; setæ very conspicuous, obtuse, projecting and embedded in trama, dark brown. This species is the cause of the brown-root disease of Hevea in Ceylon and the Dutch East Indies. The species was also described as *F. williamsii* Murr. and also incorrectly referred to *F. endothejus* Berk. It is closely related to *F. pachyphloeus* Pat. (*F. melanodermus* Pat.), which, however, has colored spores.

F. lignosus=*Polyporus lignosus* Kl.

F. lucidus (Leys.) Cke.=Ganoderma but not *G. lucidum* (Leys.) Karst. On dead wood, Ceylon.

F. marmoratus Berk. On fallen trunks, Amazon region.

F. pseudoferreus Wakefield. Wet-rot fungus, originally misdetermined for *Poria hypolateritia.* Erroneously considered by Van Overeem and Steinmann to be identical with *F. ferreus* Berk.=*Ganoderma ferreum* (Berk.) V. O. and St. See Ganoderma.

F. semitostus (Berk.) Cke. Mistaken determination for *F. lignosus.*

Fracchiaea brevibarbata (B. and Br.) Petch. On branches, Ceylon.

F. depressa Petch. On branches, Ceylon.

F. hystericula (B. and Br.) Petch. On dead wood, Ceylon.

Fusarium heveae Vincens. Sporodochia arranged in concentric circles around a central one, pale pink; conidiophores branched, 3 to 5 μ in diameter; conidia fusiform, slightly curved, 1 to 5 septate, usually 3-septate, 15 to 50 by 3 to 7 μ. On leaves, Para. See *F. diversisporum* Sherb. (Syd., Ann. Myc., XV, 267, 1917.)

F. theobromae Appel and Strunk. Mentioned by Wollenweber in his Fusaria (autogr. del.) as occurring on Hevea.

F. sp. On fruits parasitized by Phytophthora, Amazon region; bark, Ceylon; root disease in nurseries, Dutch East Indies; branches, India.

Fusicladium macrosporum Kuyper=*Dothidella ulei.*

F. sp. On stem canker and leaves, Dutch East Indies; on bark, Malay Peninsula; canker, Ceylon.

Ganoderma amazonense Weir, n. sp. Pileus thin, hard, rigid, persisting, single or imbricate, laterally concrescent with development of small pileoli on surface or at the margin, 4 to 10 by 5 to 9 by 1 to 10 centimeters; surface gray to brown, incrusted, smooth, concentrically zonate; margin thin to obtuse, lobed, white when growing; context corky, light buff, slightly light brown next the pores, 2 to 10 millimeters; pores stratified in old specimens, about 1 millimeter long each season, 3 to 4 per millimeter, whitish stuffed in some specimens; pore mouths regular, grayish white, discolored when bruised; edges obtuse, slightly granular; dissepi-

ments thick, light brown; dissepiment context concolorous with adjoining context of pileus; spores ovate to ellipsoid, conspicuously punctate, brown, sometimes obliquely apiculate, slightly truncate at one end, uniguttulate, average (50) 7.7 by 5.5 μ; tramal hyphæ simple, rarely branched undulate, diameter average 2.3 μ; context hyphæ more branched, undulate, diameter average 2.8 μ. Substrata: On wood of various jungle trees, especially Hevea. Type in Pathological Collections (No. 62043), U. S. Department of Agriculture.

G. australe (Fr.) Pat. On dead roots of living tree, Amazon region.

G. ferreum (Berk.) V. O. and St. Incorrect generic reference of the type specimen.

Q. pseudoferreum (Wakefield) V. O. and S.

Gloeosporium alborubrum Petch. Acervuli submerged, scattered or confluent, 120 to 200 μ in diameter, black when young, pink fading to white when mature; spore mass pink, white when old; spores oblong-cylindric, straight or sometimes curved, both ends obtuse, 14 to 21 by 3 to 4 μ often issuing in tendrils. On living leaves and fruit. Although it has been shown by La Rue and Bartlett that in all probability *G. alborubrum* and *G. heveae* are identical, the latter species is retained, for the reason that on some of the leaf spots the fructifications were always of a light-brown color and never pink at any stage of development. There are also slight differences in spore characters.

G. brunneum. On leaves, Ceylon, Malay Peninsula.

G. elastica Cke. and Mass. On leaves, Java, Ceylon. Said to be identical with *Colletotrichum ficus* Kds., *Neozimmermannia elasticae* Kds., and *Glomerella cingulata* (Stonem.) S. and V. S.

G. heveae Petch. Acervuli brownish, scattered, flattened, somewhat erumpent on both sides of the spots; spore mass pale brown; spores oblong-cylindric, sometimes curved with one end acute, usually both ends rounded, hyaline or slightly greenish, average 15.5 by 4.5 μ, basidia 18 to 29 by 2 μ. On living leaves, Amazon region, Ceylon, Malay Peninsula.

G. sp. Acervuli white, scattered or confluent, erumpent, amphigenous, spore masses hyaline; spores irregular oval to cylindrical, but usually peanut shaped, constricted in the middle or budding at the ends, hyaline, on short elbow stalks, average 6.5 by 2.1 μ. On living leaves, Amazon region.

Glomerella cingulata (Stonem.) S. and V. S. See *Gloeosporium elastica.*

Guignardia heveae Syd. On leaves, Ceylon, Malay Peninsula.

Haplosporella crypta Petch. On branches, Ceylon.

Helicobasidium (?) H. Mompa Tamnaka. Root disease, Malay Peninsula.

H. sp. In Uganda; later found on cacao and described as a new species, *H. longisporium* Wakefield.

Helminthosporium heveae Petch. Spots circular with purple-brown margins, 1 to 4 millimeters in diameter; conidiophores simple, scattered, olivaceous, 70 to 200 μ long; conidia cymbiform, 8 to 11 septate, brown 100 to 200 by 15 to 18 μ. On leaves, Amazon region, Ceylon, Dutch East Indies.

Heterochaete andina Pat. and Lagh. On dead branches of living tree, Amazon region.

H. tenuicula (Lev.) Pat. On dead wood, Ceylon.

Hexagonia cervino-plumbea Jungh. Reported on Hevea in the Orient=*H. tenuis.*

H. polygramma Mont. On dead wood, Ceylon.

H. pulchella Lev. Regarded by some as a small-pore form of *H. tenuis.* Java.

H. tenuis (Hook). On dead branches of living trees, Amazon region, Orient.

H. thwaitesii Berk. Reported on Hevea in the Orient=*H. tenuis.*

Hirneola hispidula B. and Br. On dead Hevea, Ceylon.

H. polytricha Mont. See Auricularia.

Hydnum villipes Lloyd. On dead stems, Amazon region.

Hymenochaete noxia Berk.=*Fomes lamaoensis* Murr.

Hypochnus sp. Thread-blight, Malay Peninsula.

Hypocrea borneensis Yates. On decaying log, British North Borneo.

H. sp. On stem and branch, Malay Peninsula.

Hypocrella ceramichora (B. and Br.) Petch. On Lecanium infesting Hevea, Ceylon.

H. reineckiana P. Henn. On scale insects on leaves, Ceylon and other tropical regions.

H. verruculosa Möller. Stroma yellowish brown, hemispherical, verrucose or granular, 2 to 4 millimeters in diameter; perithecia scattered, submerged, flask shaped, about 600 μ with long necks; asci 270 to 300 μ long, 4-spored; spore filamentous, breaking up into numerous oval division spores, which are 12 to 15 by 3 to 5 μ. On stems and twigs, Amazon region.

Hypolissus montagnei Berk. Amazon region.

Hypoxylon bipapillatum B. and C. On dead branches and old tapping scars, Amazon region.

H. haematostroma Mont. On dead stems, Amazon region.

H. oodes B. and Br. On dead branches, Malay Peninsula.

H. polyspermum of authors, not Mont. On dead branches and stems, Amazon region.

H. rubiginosum (Pers.) Fr. On dead branches attached to living trees, Amazon region.

H. sclerophlocum B. and C. On dead bark around tapping cuts and on trees injured by fire, Amazon region.

Hysterium heveanum Sacc. Malay Peninsula.

Irpex canescens Fr. On dead wood, Amazon region.

I. flavus Jungh.=Polystictus.

Kretzschmaria apoda Rick. On dead stump, Amazon region.

K. botrytis Lloyd. On dead stem, Malay Peninsula.

K. coenopus (Fr.) Sacc. On dead bark around tapping wounds and old mistletoe burls, Amazon region.

K. lichenoides Rick. On old tapping wounds, Amazon Valley.

K. micropus (Berk.) Sacc. On stems, Ceylon.

K. pechuelii P. Henn. On decaying log, British North Borneo.

Lasiodiplodia nigra. On fruit, Kamerun.

L. theobromae (Pat.) Griff.=*Diplodia theobromae* (Pat.) Nowell.

Lembosia glonioides Sacc. On dead limbs, Malay Peninsula.

Lentinus crinitus (L.) Fr. On dead wood, Amazon region.

L. lencochrous Lev. On dead branches, Singapore.

L. nigripes Fr. On dead wood, Amazon region.

L. similis. On decaying stump, Ceylon.

L. strigellus B. and C. On dead wood, Amazon region.

L. velutinus Fr. On dead wood, Amazon region.

Lenzites repanda (Pers.)=Daedalea. On dead wood, Malay Peninsula.

L. striata Lev. On dead branches of living trees, Amazon region.

Leptosphaeria sp. On whitish gray spots, with a faint purplish tinge progressing uniformly from the tips of the leaves, occupying almost the entire surface of the leaf, and bounded by a brown zone. Diseased area beneath whitish gray; perithecia submerged, spherical, dark colored, ostiole prominent; asci clavate, 8-spored, 45 to 58 μ long by 11 μ thick; paraphyses hyaline, straight, filamentous; spores fusiform, obtuse at both ends, 5-septate, cells occasionally uniguttulate, dark olivaceous, average 22 by 4.9 μ. On leaves, Amazon region.

L. sp. On apices of stems, Uganda.

Limacinia javanica Sacc. Sooty mold, Malay Peninsula.

Limacinula javanica V. Hohn. Sooty mold following *Lecanium nigrum* on leaves, Malay Peninsula.

Lopharia mirabilia (B. and Br.) Pat. On dead Hevea, Ceylon, Malay Peninsula.

Macrophoma sp. On ruptured bark over old rubber pads and on seeds on ground and in dead pods hanging to tree, Amazon region.

M. vestita Prill. and Del.=*Diplodia theobromae.*

Macrosporium sp. On leaves, Ceylon.

Marasmius equicrinus Muell. On stems and leaves, Amazon region.

M. rotula Berk. and Br. On stems, Ceylon.

M. sarmentosus Berk. Mycelium on bark of young Hevea, Amazon region.

Massarina biconica Petch. On dead branches, Ceylon.

Megalonectria pseudotrichia (Schw.) Speg. Perithecial stage of *Stilbella cinnabarinum* Mont. On dead bark, Amazon region, Ceylon.

Melanopsammopsis heveae Stahel=*Dothidella ulei.* South American leaf-blight.

M. ulei (P. Henn.) Stahel=*Dothidella ulei.* South American leaf-blight.

Meliola amphitricha Fr. On leaves with *Catacauma huberi*, Amazon region.

M. heveae Vincens. Mycelium inconspicuous, 6 to 9 μ in diameter, forming small black patches 1 to 3 millimeters in diameter, dichotomously branched, septate and constricted at the septa; perithecia globose, about 245 μ in diameter, black; asci elliptic, 2-spored, 60 to 70.5 by 38 to 51 μ; spores ovoid, elongate, 4-septate, constricted at the septa, 45 to 50 by 16 to 18 μ; setæ brown, swollen at the base, 60 to 55 by 9 to 12 μ. On living leaves, Amazon region.

Microthryium sp. On green shoots, Amazon region.

Necator decretus Mass.=stage of *Corticium salmonicolor*.

Nectria bicolor B. and Br. On Hevea log, Ceylon.

N. bomba Petch. On dead log, Ceylon.

N. cancri Rutgers. On dead wood, Ceylon.

N. coffeicola Zimm. On dead branches, Java.

N. diversicola. Canker on bark.

N. diversispora Petch. Canker on stems and fruits, Ceylon.

N. (Dialonectria) gigantospora Zimm. On leaves, Java.

N. haematococca B. and Br. On dead trees, Ceylon.

N. rigidiuscula Petch. On dead wood, Ceylon.

N. sanguinea Fr. On dead bark, Malay Peninsula.

Neotrotteria pulchella Sacc. On dead branches, Malay Peninsula.

Neozimmermannia elasticae Kds. On leaves, Java. See *Glocosporium elastica*.

Nummularia anthracodes (Fr.) Cke. Stroma widely effused, developing in the cortex under the outer cork layer (which exfoliates, exposing the fructification), closely attached over entire surface to the bark beneath, 1 to 2 millimeters thick, brittle smoky black, shining when weathered, smooth, covered with small craterlike ostioles; ostioles slightly erumpent; perithecia oval to cylindrical, densely crowded in one layer, reaching 1,500 μ in height by 300 μ in diameter; asci clavate-cylindrical, 100 to 110 by 6 to 8 μ; spores 8, uniseriate, fusoid-navicular, light brown to translucent, becoming dark brown and opaque, 15 to 18 by 6 to 8 μ, occasionally reaching 25 by 8 μ; expelled in glutinous masses about the ostiola below the exfoliated outer bark. On tapping wounds, mistletoe burls, etc., Amazon region.

N. cincta Ferd. and Wgl. On old tapping bark, Amazon region.

N. commixta Rehm. On dead bark of fire scars and on tapping cuts attacked by borers. Amazon region.

N. pithodes (B. and Br.) Petch. Described in connection with the diseases of Hevea in Ceylon. Closely related to *N. anthracodes*. The species was originally referred to the genus Diatrype and by Saccardo to Anthostoma. *Eutype caulivora* Mass. is considered by Petch identical with these two species.

N. punctulata Sacc. Malay Peninsula.

N. repandoides Fel. var. *singaporensis* Sacc. Malay Peninsula and Dutch East Indies.

Odontia sp. On dead branches of living tree.

Oidium heveae Steinmann. On leaves, Dutch East Indies.

Omphalea sp. On dead twigs, Amazon region.

Oospora gilva Berk. Pink fungus on burned wood, Malay Peninsula.

Ophiobolus heveae P. Henn. Perithecia appearing on gray patches on the upper side of the leaf, scattered or gregarious, submerged, erumpent, black, oval or globose, about 250 μ in diameter; asci fusiform or clavate, obtuse and thickened at the ends, 8-spored, 60 to 70 μ long by 7 to 10 μ thick; spores filamentous, parallel in the ascus, hyaline, rounded at the ends, multiseptate, guttulate, 50 to 60 by 2 to 3 μ; paraphyses present, filamentous, hyaline, about 2 μ thick. On Hevea, Brazil.

Ozonium sp. On dead branches, Philippine Islands.

Parodiella melioloides (B. and C.) Wint. Perithecia spherical, reddish cinnamon, mostly on the under side of the leaf, arranged concentrically or irregularly massed on a superficial brownish mycelium and surrounded with septate branched reddish brown hyphæ; asci elongate-ovate to clavate, somewhat stalked, 8-spored, 80 to 120 by 30 to 40 μ; spores clavate, hyaline, then brownish, irregularly 2-seriate, rounded at both ends, 1-septate, slightly constricted 40 to 45 μ long by 12 to 14 μ broad. On leaves of Hevea, Brazil.

Parodiopsis perae Arnaud. On Euphorbiaceæ, considered by the writer as possibly identical with *Parodiella melioloides*.

Passalora heveae Mass. See *Dothidella ulei.*

Patellina rosea Petch. On dead wood, Ceylon.

Penicillium spp. On various dead parts, Amazon region.

Peniophora cinerea Fr. On stems of living seedlings, Amazon region.

P. sp. Common on dead branches of living trees and causing a decay in the branch collar, Amazon region.

Periconia byssoidea Pers. On leaves, associated with Gloeosporium and other leaf fungi, Amazon region.

P. pycnospora Fres. On injured leaves, Ceylon.

Peroneutypa heteracanthoides Sacc. On dead limbs, Malay Peninsula.

Pestalozzia guepini Desmaz. On leaves and stems of seedlings, Ceylon.

P. palmarum Cooke. Acervuli flattened to erumpent, dark colored, submerged; spores fusiform, 4-septate; terminal cells hyaline with three hyaline setæ; middle three cells dark brown; inclusive of the two hyaline apical cells, average 18.1 to 25 by 5 to 10 μ; three colored cells 12 to 18.5 by 5 to 10 μ, setæ up to 25 or 30 μ long. On living and dead parts, Dutch East Indies, Malay Peninsula, Ceylon, Amazon region, Uganda.

P. sp. On leaves in nurseries, Ceylon.

Phaengella heveae Mass. On bark, South Nigeria.

Phlyctaena heveae Petch. On branches, Ceylon.

P. sp. On leaves, Cochin China.

Phoma aterrima Petch. On fruit, Ceylon.

P. heveae Petch. Pycnidia black, hemispherical, gregarious, immersed, slightly prominent, 0.1 to 0.2 millimeter in diameter; spores elliptic, hyaline, 4 to 5 by 2 μ (Petch). On branches, Ceylon.

P. ramicola Petch. On branches, Ceylon.

Phomopsis sp. On branches, Uganda.

Phyllachora huberi Henn.=*Catacauma huberi* (P. Henn.) Theiss. and Syd.

Phyllosticta heveae Zimm. Affected areas show on both sides of the leaf light yellowish brown, without definite colored margin; pycnidia scattered, epiphyllous, subepidermal, erumpent, brown, edges of ostiolum black, 75 to 156 μ in diameter; ostiolum 16 μ in diameter; spores elongate-elliptic or pointed at one end, faintly biguttulate, hyaline, average 7 by 2.2 μ. On living leaves of *Hevea brasiliensis* and *H. guyanensis*, Amazon region, Java, Ceylon, Malay Peninsula.

P. ramicola Petch. Pycnidia 0.1 to 0.25 millimeter in diameter, black, subepidermal, crowded, slightly prominent, lenticular, 75 to 140 μ high; spores narrow-oval, ends acute, often biguttulate, greenish hyaline, 8 to 12 by 2 to 3 μ, issuing in a fine white tendril (Petch). On green stems, Ceylon, Java, Malay Peninsula.

P. sp. Spots on both sides of the leaf, round or irregular (later involving the margin and large areas of the leaf surface), reddish brown at first, becoming gray on the upper side of the leaf with reddish brown margin, constantly reddish brown beneath; pycnidia scattered, epiphyllous, black, subepidermal, slightly erumpent, lenticular, ostiolate, 100 to 125 μ in diameter; spores ellipsoid, ends usually obtuse, often biguttulate, greenish hyaline, average (50) 5.2 by 2.2 μ. On leaves, Amazon Valley.

Phyllostictina sp. On irregular small or broadly expanding reddish brown areas; pycnidia gregarious or scattered, slightly erumpent, mostly submerged, subglobose or lenticular, black, papillate, ostiolate; spores globose or subglobose, sometimes slightly elliptic, hyaline, multiguttulate when young, smooth, average 7.3 by 6.1 μ; spore masses mucilaginous, adhering, on living leaves. The fungus is not to be confused with immature spores of *Diplodia theobromae*. The genus Phyllostictina Syd. was emended by V. Höhnel as follows: "Stroma imperfectly developed, in or under the epidermis, sometimes merely indicated by loosely intertwined dark-colored hyphæ; pycnidia small, scattered or stromatically gregarious with indefinite ostiola; conidiophores simple, soon disappearing; conidia globose to broadly ellipsoid, smooth, hyaline, unicellular, delicate cell walls with uniform granular content. Spore form of Guignardia Viala and Rayaz and possibly also related Phyllachoraceæ." See *G. heveae* Syd., Ann. Myc. vol. 14, p. 360, 1916. On *Hevea brasiliensis*, Los Banos, Philippine Islands.

Physarum viride Pers. On dead branches, Malay Peninsula.

Phytophthora faberi Maubl. Mycelium extensively branched, continuous when young, becoming septate when older; hyphæ 2 to 5.5 to 10.2 μ in diameter, intercellular and intracellular, superficial; sporangia numerous, on sympo-

dially branched sporangiophores, ovate or elongated, 25 to 95 by 17 to 36.5 μ; conidia spherical 22 to 52 μ in diameter. On leaves and fruits, Amazon region.

P. meadii McRae. Mycelium branched, continuous when young, becoming septate when older; hyphæ 3 to 6.3 to 10.8 μ in diameter, intercellular and intracellular, superficial; sporangia variable, usually obtuse pyriform, borne terminally or laterally on long or short branched sporangiophores, average about 26 to 56 by 15 to 27 μ. On fruits, Amazon region.

P. omnivora De By. Ceylon, Java; reported by Vincens not found in Cochin China.

Pimina sp. Parasitic on Botrytis on *Dothidella ulei*, Amazon region, Dutch Guiana.

Pleonectria heveana Sacc. On dead trunk, Malay Peninsula.

Pleurotus angustatus B. and Br. Decay of tapped area, Ceylon.

P. flabellatus B. and Br. On dead wood, Ceylon.

P. sp. The species is small, dark colored, with pointed cystidia. On dead bark of tapping wounds, Amazon region.

Polyporus fimbriatus Fr. On dead branches, Amazon region.

P. flavus Jungh.=Polystictus.

P. grammocephalus Berk. On dead limbs, Malay Peninsula.

P. lignosus Klotzsch. Pileus flexible, soft, drying hard and rigid, persisting and often reviving (sub-Polyporus), sessile, imbricate, laterally connate, convex or applanate to wholly resupinate, 3 to 15 centimeters long by 3 to 25 centimeters broad, 3 to 15 millimeters thick; surface multizonate, glabrous to silky, slightly concentrically sulcate and radially striate, conspicuously red-brown zonate, alternating with bands of yellow and orange, drying pale yellow-brown with concentric red-brown lines, not incrusted; margin thin, entire to lobed, yellowish when fresh, white in young resupinate specimens; context white to very light buff, rather soft brittle or fibrous, 3 to 5 millimeters thick, up to 1.5 centimeters in some specimens; pores sometimes in 2 to 4 layers, about 2 millimeters each season, 9 to 10 per millimeter; pore mouths angular to circular, orange when fresh, drying pinkish to red-brown; edges acute, even; dissepiments thin, permanently red-brown when dry in young specimens, color in old examples more or less confined to the pore mouths and darker than the context; spores globose, smooth, hyaline, 3½ to 5 by 3 to 3.8 μ; cystidia hyaline, few acute dilated at base; tramal hyphæ irregular, usually simple, occasionally septate, thick walled, average 2 to 4 μ; context hyphæ with thinner walls, usually larger, 2 to 7 μ. On roots of *Hevea brasiliensis* and of many jungle trees. Decay white to yellowish, undifferentiated. The species was referred to *F. semitostus* in the early pathological literature on Hevea, but is an entirely different species. Some of the synonyms of *Polyporus lignosus* are *P. kamphöveneri* Fr. and *P. diffusus* Fr. The species is closely related to *F. auberianus* (Mont.) Murr. Van Overeem considers *Polyporus lignosus* and *P. zonalis* to be identical. This view appears to be untenable.

P. mesotalpae Lloyd. Root disease, Ceylon.

P. rugulosus Lev.=*Polyporus zonalis* Berk.

P. williamsii Murr.=*Fomes lamaoensis* Murr.

P. zonalis Berk. Pileus flexible when fresh, hard and rigid when dry, persisting, sessile, imbricate, convex or applanate to resupinate, rarely more than 4 centimeters long by 6 centimeters broad and 6 millimeters thick; surface with alternating bands of reddish brown, gray, or pale-tan color, conspicuously concentrically grooved, rarely radially striate, glabrous or alternating glabrous and pruinate zones, usually incrusted. Margin thin; entire, or undulate; context pale brown or tan, hard, fibrous, 1 to 3 millimeters thick; pores rarely stratified, 1 to 3 millimeters long, 9 to 10 per millimeter; pore mouths angular, pink or flesh colored when fresh, drying to whitish, brownish or wood color; edges thin, finely granular; dissepiments thin, permanently wood color when dry, darker than the context; spores globose, smooth, hyaline, usually 1-guttulate, 4 to 5 by 3½ to 4½ μ; cystidia hyaline, inconspicuous pointed or obtuse; tramal hyphæ long, somewhat undulate, simple, rarely septate, thick walled and pseudosclerenchymatous, larger hyphæ average 4.7 μ in diameter; context hyphæ straight, more often septate, very thick walled, larger hyphæ average 8.2 μ in diameter; intermingling smaller thinner walled, hyphæ in both trama and context. On roots of living *Hevea brasiliensis* and of many jungle trees. Decay, white, yellowish white, usually firm, differentiated with small pits or

pockets in final stages. This species has been described under a variety of names. It is best known under the above name. Some of its synonyms are *Polyporus surinamensis* Miq., *P. rigidus* Berk., *P. rufopictus* (B. and C.) Cke., and *P. rugulosus* Lev. The species extends into the Temperate Zone and if not the same is closely related to *Polyporus undatus* Pers.

Polystictus atypus (Lev.) Bres. On dead stump, part of which was living, Amazon region.

P. flavus (Kl.) On dead wood, Orient.

P. hirsutus Fr. On dead stumps, Singapore.

P. (Irpex) farinaceus Fr. On dead branches, Amazon region.

P. persoonii Fr. See Trametes.

P. sanguineus (L.) Fr. On dead branches, fire scars, Amazon region; on dead wood, Malay Peninsula.

Poria albocincta Cke. and Mass. (*P. aurantiotingens* Ellis and Macbr.). Sporophore effused, persisting, hard; subiculum inconspicuous; margin whitish, soon abrupt; pores very short, dædaloid, with free walls, not continuous with those of the previous season, soon becoming entirely obscured or filled with crystalline deposits 10 to 18 per millimeter; pore mouths at first light gray to slate color, becoming smoke color to black when old; dissepiments thin, gray, or black, edges becoming lacerate with crystalline deposits; spores ovoid, smooth, hyaline, average (50) 3.5 by 2.5 μ; cystidia none; tramal hyphæ parallel, with long axis of pore thick walled, fuscous or brownish black in mass; subicular hyphæ yellowish orange, conspicuously branched, thick walls; lumina large, subpseudosclerenchymatous, staining wood a bright ange; rot light yellowish or white, usually hard and compact but may become soft and spongy in some woods. On Hevea and other woods, Amazon region. In color of the pores the species resembles *P. ravenalae* Berk. and Br. (*P. fuligo* Berk. and Br., *P. nigra* Berk. and Br., not *P. nigra* (Berk.) Cke. from Ohio, *P. buttneri* Henn., *P. glauca* Pat.). *P. ravenalae*, however, grows only on palms and does not color the wood red. The pores are also larger and not dædaloid.

P. borbonica Pat. (*P. cinereicolor* Murr.). Sporophore effused, persistent, firm; subiculum inconspicuous; margin white, soon obsolete; pores 5 to 6 per millimeter, angular; pore mouths cinereous gray; dissepiments thin, glaucous when old, with brownish context; basidial layer conspicuous; spores broadly ellipsoid, ovate or flattened on one side, smooth, hyaline, average (50) 2.3 by 3.5 μ; cystidia not well defined, large obtuse crystallike bodies embedded in the trama and rarely projecting are present; hyphæ in wood branched, brownish yellow with reddish tinge; rhizomorphs when present brownish red, sometimes with white fimbriate extensions. Surface wood stained a conspicuous brick red. Rot white, firm, becoming friable in some woods. Found on Hevea and other trees, Amazon region.

P. graphica Bres. (*P. lateritia* Pat.). Sporophore effused, perennial, hard; subiculum indistinct, sometimes showing as a dark line; margin white when young, becoming abrupt; pores conspicuously stratified in fine narrow lines less than one-half millimeter long each season, 5 to 6 per millimeter, frequently in parallel rows or labyrinthiform, angular, old layers solid filled and of a conspicuous brick-red color; pore mouths gray to reddish, cinereous when young, becoming brownish red with age; dissepiments thin, grayish with reddish context; spores ovate to ellipsoid, smooth, hyaline, average (50) 2.4 by 4.6 μ; cystidia none; hyphæ yellowish with reddish content. Conspicuous white cords tinged or streaked with red are sometimes developed between the bark and wood. Red lines in the wood are frequently apparent, but the red color is mostly confined to the surface wood. The decay is white to yellowish and firm. Found on the wood of Hevea and other trees, Amazon region.

P. hypobrunnea Petch. Sporophore extensively effused, reviving, pliable when fresh, hard and brittle when dry; subiculum thick, conspicuous in well-developed specimens, dark brown to black, compact floccose when torn and when on irregular surfaces, inseparable from substratum except on smooth decorticated wood; margin white when young, pubescent, soon concolorous with pores; pores rarely stratified, 1 to 3 millimeters long, 9 to 10 per millimeter, regular to angular; pore mouths even, slightly granular, yellowish white when young, becoming pink or rose color to reddish brown, sometimes with a glaucous or grayish tinge, eventually

gray and discolored when old; dissepiments thin, concolorous with pore mouths at top, concolorous with subiculum at base; dissepiment context light brown, merging to darker color of subiculum; basidia 4-spored clavate, 11 to 15 by 2.4 to 4 μ; spores globose, sometimes flattened on one side to almost short allantoid, rarely broadly ellipsoid, smooth, hyaline, variable in size, average (50) 3.6 by 3.2 μ; cystidia crystalline hyaline, short projecting or embedded, obtuse, conspicuous, rarely incrusted, irregularly distributed, smaller smooth hyaline cystidia also present; subicular hyphæ slightly undulate, simple to rarely branched, slightly colored to dark brown in mass, 2 to 4 μ in diameter; tramal hyphæ simple, hyaline, slightly pseudosclerenchymatous, 2 to 3 μ in diameter; mycelial strands smooth, tough, red to brownish red or black when old, white internally. Originally described from Ceylon, where it is said to pass over from the roots of jungle trees and to cause a serious disease of the roots of tea and Hevea.

P. hypolateritia (Berk.) Cke. Effused, reviving, hard and brittle when dry; subiculum in type inconspicuous, white, lower surface reddish horny; margin white pubescent when young, becoming obsolete and concolorous with the pores; pores unstratified, 7 to 8 per millimeter, angular, pore mouths even, whitish when young, later pink or flesh colored; dissepiments thin; spores curved to ellipsoid, smooth hyaline, average 3.7 to 4 by 1.2 μ; cystidia inconspicuous, slightly projecting, crystalline bodies absent from trama; tramal hyphæ simple, rather thick walled, but not appearing pseudosclerenchymatic; mycelial strands white, soft when young, becoming hard and tough and red or dark red when old. This species came originally from India. Because of its affinity to *P. vincta* and its possible occurrence in tropical America it is included here. It is said to cause a serious disease of tea roots in India and Ceylon. It has been reported on Hevea, and is probably the cause of the wet-rot referred to *Ganoderma pseudoferreum*, since no Ganoderma is known to produce a reddish crust or skin on diseased roots.

P. mollopora (Murr.) Sacc. and Trott. On dead stumps, roots, and trunks and on dead branches attached to living trees; Amazon region.

P. subserpens (Murr.), comb. nov. On dead branches on living trees 20 to 40 feet above ground.

P. vincta (Berk.) Cke. Effused to a large or small extent (depending upon shape, size, and position of substratum), seasonal, reviving, pliable when fresh, hard and brittle when dry; subiculum conspicuous in type, brown (probably faded with preservatives and not typical for this species), inseparable from smooth substrata, under surface reddish, horny, and loosely attached to irregular surfaces; margin white, fimbriate, tomentose when young; pores unstratified or inconspicuously stratified in some specimens, 1 to 3 millimeters long, 9 to 10 per millimeter, regular to angular; pore mouths even, slightly granular, yellowish white when young, becoming pink or rose color to reddish brown, sometimes with a glaucous or grayish tinge; dissepiments thin, concolorous; dissepiment context light brown, darker below; basidia 4-spored, clavate, 11 to 15 by 2.4 to 4 μ; spores globose to rarely broadly ellipsoid, smooth, hyaline, average (50) 3 to 4 by 3.2 μ; cystidia crystalline, projecting or embedded, conspicuous, incrusted, irregularly distributed, smooth projecting cystidia also present; subicular hyphæ simple, colored slightly darker in mass, 2 to 4 μ in diameter; tramal hyphæ slightly pseudosclerenchymatous, simple, 2 to 4 μ in diameter; mycelial strands white, soft, fimbriate at extremities when young, becoming red or dark red when old. The globose and ellipsoid slightly striate colored spores so abundant in the type of *P. vincta* are those of a Hyphomycete. This species was originally described from material collected by Sallé (No. 34) in Santo Domingo and has since been collected throughout the American Tropics on the wood of various trees. Specimens have been examined from Africa. There is much in common between this species and *P. hypobrunnea* on Hevea in the Orient. The types of both species have conspicuous incrusted cystidia in the hymenium or embedded in the trama appearing as crystalline bodies when viewed in cross section; hyaline smooth cystidia are also present. The hyphæ, owing to their thick walls, have a slight pseudosclerenchymatous appearance in cross section. Reddish rhizomorphs, frequently with whitish fimbriate extremities, are present in both species; their spores are globose to broadly ellipsoid, and the character of decay is the same. In the herbaria

P. vincta is sometimes confused with *P. collabens* Fr., a common species in the Temperate Zone and also found in southern Florida and Central America. The two species are similar in structure and appearance, but the latter is of a permanently deeper red, has larger and more conspicuous incrusted cystidia, spores typically allantoid, margin soft and spongy when present, and the pink soft spongy mycelial sheets in the substratum never coalesce to form rhizomorphs. It is moreover confined to coniferous wood. *P. collabens* Fr. is also known under the following names: *P. aurantiaca* (Rostk.) Sacc., *P. emollita* Fr. (in part), *P. blytii* Fr., *P. vincta* (Berk. ex Centr. Prov. Amer. No. 208, not type det. Berkeley), *P. incarnata* Fr. (Icon Selec. tab. 189 f. 1., not Syst. Myc., not Pers.), *P. rixosa* Karst, *P. aurantiaca* Rostk. var. *salviscensis* Karst, and *P. dodgei* Murr. Another species with which *P. vincta* could be confused is *P. nitida* Pers. This species occurs in subtropical regions on frondose wood. It has larger pores than *P. vincta* and has ellipsoid spores, but, as in the other two species, incrusted cytidia are present in the hymenium. The synonymy of *P. nitida* is as follows: *P. cupora* Karst, *P. micans* Rostk., *P. attenuata* Pk., *P. blyttii* Fr. var. *lutescens* Fr. (in herb.).

Protostegia hevеae Charles, n. sp. Pycnidia subimmersed, cupuliform, orbicular, fuscous black, membranaceous, scattered, margin 8 to 11 lacinate-stellate, 75 to 100 μ in diameter; spores 5 to 7 fasciculate-pedicellate, pedicel 8 μ in length, hyaline, aciculate-falcate, 5 to 7 septate, 2 to 3 by 15 to 36 μ, mostly 30 to 36 μ in length. On dead twigs of *Hevea brasiliensis* Weir, Para, Brazil. Type in Pathological Collections (No. 72524), United States Department of Agriculture. Cooke in his generic diagnosis of Protostegia (Grev. vol. 9, p. 19) describes the spores as simple or septate. The type species *P. eucleae* is given as 3 to 5 septate. Saccardo (Sylloge III, p. 690) describes the spores as continuous and places the type species *P. eucleae* in the genus Pilidium, which genus, however, was described by Kunze (Mykologische Heft; Gustav Kunze, Heft. 2, p. 92, Leipzig, 1823) as having fusiform spores, the type species, *Pilidium accrinum*, conforming to this description. In view of the original description of the type species of the genus Protostegia this species is placed in this genus.

Rhizopus nigricans Ehr. Mycelium dark brown at maturity; rhizoids numerous, branched, black-brown when mature; sporangiophores in tufts, erect, simple, dark brown; sporangia globose, white when young, black-brown when mature, 100 to 350 μ broad; columella large, hemispherical; spores pale to brown, irregular, 6 to 17 μ long. On inflorescence in damp situations, Amazon region.

Rigidoporus microporus (SW.) Van Overeem, recently used for *Polyporus lignosus*.

Rosellinia bunodes (B. and Br.) Sacc. Perithecia superficial, embedded at first in a purple-brown velvety mycelium, gregarious, brown to black when old, spherical, roughened with wartlike scales arranged concentrically, 1 to 1.8 millimeters in diameter; ostiola sometimes not conspicuous; asci fusiform, stalks rather long, 200 to 300 μ long by 12 to 16 μ broad, 8-spored; spores fusiform, somewhat irregular in outline, with threadlike appendages at both ends, black-brown, 80 to 110 μ long (without appendages) by 7 to 12 μ broad; conidia hyaline. On roots of Hevea and associated trees, Amazon region, Dutch East Indies.

R. hystricula B and Br.=Fracchiaea.

R. paiggarii Pat. Perithecia connivent in groups, 3 centimeters or less in diameter, seated upon rough pseudostromatic subicula; perithecia rarely exceeding 2 millimeters in diameter, usually borne upon a stipe 1 millimeter or less in length; ostiole prominent, surrounded by a smooth circular area about 1 millimeter in diameter, rest of perithecial surface slightly granular, roughened; perithecial cavity spherical, reaching 1.5 millimeters in diameter; asci clavate, cylindrical, short or long stipitate; spores navicular, acute to subumbonate, light to dark brown to opaque, 33 to 45 by 8 to 15 μ. On dead wood, Rio Madeira, Brazil.

R. subiculata (Schw.) Sacc. Perithecia scattered to gregarious, rarely crowded, subglobose, 1 to 1.5 millimeters in diameter, seated on the incrusted remnant of subiculum, dull dark brown, ostiole papilliform; asci not seen; spores subinequilateral, 12 to 14 by 5 to 6 μ. On dead roots, Amazon region.

R. sp. Black-root disease, Granada (Ballou), Gold Coast (Bunting), Dominica (Jones).

Schizophyllum commune Fr. On dead wood. Orient, Amazon region.
Sclerotium sp. Reported on tapping cuts, Java.
Scolecotrichum. See *Dothidella ulei.*
S. heveae Vincens. Conidiophores slightly swollen at base, brown, erect, 150 to 200 μ high, 6 to 8 μ in diameter; conidia irregularly oval, catenulate, continuous. On leaves of *H. brasiliensis*, Para.
Septobasidium atratum Pat. On branches, Rio Jurua, Amazon Valley.
S. frustulosum (Berk. and Curt.) Pat. Resupinate, coriaceous to rigid, velutinous, honey yellow or darker, margin sinuous, reticulate, 3-layered, without pillar formation; protobasidia pyriform, hyaline, septate; spores cylindric, hyaline, 13 to 18 by 4 to 5 μ. On stems, Cobija, Bolivia.
S. fumigatum Burt. Resupinate, coriaceous, tomentose, mouse-gray to darker shades of brown; margin thin; middle layer loosely interwoven; protobasidia subglobose, terminating in coiled colored branches; basidia few, septate, straight, hyaline; spores cylindric or slightly curved, 11.5 to 14.8 by 5 to 6 μ. On stems, Amazon region.
Septonema exaltatum Petch. On dead branches, Ceylon.
Sphaerella heveae Petch. Rim-blight on leaves, Ceylon.
S. heveana Sacc. On dead leaves, Singapore.
Sphaeronema album Petch. On fruits, Ceylon.
S. fimbriatum (E. and H.) Sacc. Moldy rot, tapped surfaces, Malay Peninsula.
Sphaerostilbe repens B. and Br. Root disease, Ceylon, Malay Peninsula.
Spicaria sp. On bark=stage of *Calonectria cremea*, Ceylon.
Spongospora sp. On bark with brown-bast, Dutch East Indies.
Sporocybe compacta Petch. On dead branches, Ceylon.
Sporodesmium striatum Petch. On dead branches, Ceylon.
Stemonitis fusca Roth. On dead stump, Malay Peninsula.
Stereum cuneiforme Lloyd. On roots, Malay Peninsula.
S. papyrinum Mont. On dead branches, Amazon region.
S. umbrinum B. and C. On dead edges of top of living stumps affecting the formation of callus, Amazon region.
Stilbella heveae Zimm. On stem and branches, Malay Peninsula, Sumatra.
Stilbum cinnabarinum Mont. Conidial stage of *Megalonectria pseudotrichia.* On dead roots and stems, Orient, Amazon region.
S. nana Mass. On dead wood, Orient, Amazon region. Appears to be identical with *Stilbella heveae* Zimm.
Syncephalastrum sp. On living suppressed leaves in contact with decaying vegetable matter, Amazon region.
Thwaitesiella mirabilis (B. and Br.) Mass. See Lopharia.
Thyridaria tarda Bancroft. Said to be the perfect stage of *Diplodia theobromae.*
Thyridium flavum Petch. On dead branches, Ceylon.
Trametes caperatus Berk. On dead branches of living trees and dead trunks.
T. corrugata (Pers.) Bres. Wound fungus on roots of living trees. Common on dead wood, Amazon region.
T. cubensis (Mont.) Sacc. On dead trunk, Amazon region.
T. floccosa Bres. On roots of overthrown tree, Amazon region.
T. hydnoides (Sw.) Fr. On lateral roots of living stump and on dead trunks, Amazon region.
T. lachnea Berk. On dead limbs, Singapore.
T. ostreiformis Berk. On dead wood, Amazon region.
T. persoonii Fr.=*T. corrugata.*
T. rigida Berk. and Mont. On dead trunks and dead branches of living trees.
Trichothecium luteum Petch. Drying fruits in laboratory, Ceylon.
Tryblidiella leprieurii (Mont.) Sacc. Saprophytic, Ceylon.
T. mindanaoensis P. Henn. On dead bark of fire scars and twigs, Amazon region, Philippine Islands.
T. rufula (Spreng.) Sacc. On dead wood, Amazon region.
Tuberculariа versicolor Sacc. On healing surfaces, Uganda.
Ustulina maxima (Weber) v. Wettst. See *U. zonata.*
U. vulgaris Tul. See *U. zonata.*
U. zonata (Lev.) Sacc. Stroma superficial, subeffused, pulvinate, 3 to 5 centimeters or more in diameter, 2 to 6 millimeters thick, centrally attached, with thin undulating margin; surface even to undulate, sometimes concentrically zoned, white, with a layer of simple erect conidiophores bearing ellipsoidal to ovate conidia, 6 to 8 by 2 to 3 μ, then becoming greenish to whitish, gray, and eventually black and brittle; perithecia globose

to elongate, crowded, usually arranged in one row, the punctiform black ostiola slightly projecting; asci not seen, but given as cylindrical pedicellate, 8-spored, 250 by 10 μ; spores broad cymbiform to fusoid, frequently with small knob at the ends, translucent, light brown to opaque dark brown, 27 to 36 by 9 to 12 μ. On roots and stems of living trees, causing cankers, Amazon region, the Orient. Van Overeem and Steinmann consider that *U. zonata* (Lev.) Sacc. from Java and the cosmopolitan *U. vulgaris* Tul. of temperate regions are identical and that by reason of priority it should be called *U. maxima* (Weber) v. Wettst.

U. sp. Stroma superficial, extensively effused, pulvinate, 5 to 8 millimeters thick, broadly or centrally attached to substratum by a conspicuous light grayish subiculum in which are embedded black horny fibers, edges obtuse; surface fissured, not concentrically zoned, white then gray-brown, apparently never black; ostiola black, erumpent, conspicuous; perithecia cylindrical; asci and spores not observed. A very conspicuous species found on dead roots of living stumps, Madeira and Amazon Rivers.

Venturia emergens Petch. On branches, Ceylon.

Vermicularia dematium (Pers.) Fr. On stems of seedlings, Ceylon.

Verticillium sp. On bark, Ceylon.

Xylaria berkeleyi Mont. On dead fallen branches, Amazon region.

X. cynoglossa Cke. On dead root, Malay Peninsula.

X. obovata Berk. On dead wood, Malay Peninsula.

X. scopiformis Mont. On dead stems, Amazon region, Singapore.

X. scopiformis Mont. var. *heveana* Sacc. On stumps, Malay Peninsula.

X. tabacina (Kickx) Berk. On dead wood, Amazon region.

X. thwaitesii Berk. and Cke. Root disease, Ceylon.

X. tuberiformis Berk. Stumps, Singapore.

Zukaliopsis heveae Petch. On leaves, Ceylon.

Zygosporium paraense Vincens. Setæ attenuated upward, brown, lighter color at swollen apex, 30 to 50 μ high, 3 to 5 μ in diameter; basidia brown, 12 to 15 μ long, 6 to 8 μ broad, 4 to 6 μ thick, 2-spored; conidia elliptic, slightly colored, 7 to 9 by 4 to 6 μ. On leaves, Para, Amazon region.

MISTLETOES ON HEVEA

Dendrophthora poeppigii V. Tiegh. Monœcious; branches leafless, terete, smooth, olivaceous or yellowish green, internodes 2 to 9 centimeters long; branch scales spreading, acute, about 1 millimeter long; flower spikes yellowish, terminal and solitary in the axils of the scales, 0.5 to 2 centimeters long, with peduncles 2 to 7 millimeters long, 2 to 5 articulate, segments slightly enlarged above, lower segments up to 3 millimeters long, 2 to 4 flowered, upper segments shorter, terminal segment 4 to 6 flowered; flowers except on terminal segment uniseriate, upper ones of each segment male, lower or rarely all female; anthers sessile and fixed to the base of the perianth of lobes, unilocular, with one or more pollen sacs; fruit globular, pinkish, surrounded at the base by the slightly extended margin of the pit. On *Hevea brasiliensis*, Amazon Valley. This species was apparently first described by Van Tieghem in 1896 from material collected by Poeppig in the Amazon region, but no mention was made of its host. It was more fully described by Urban in 1898. Ule recorded the species on *Hevea brasiliensis* from Marary, Jurua, in 1900. This author states that it is common along the Jurua, Madeira, and Amazon Rivers. *D. heveicola* Ule is apparently the same species, but the description is inadequate. The plant could easily be mistaken for a leafless Phoradendron. According to Eichler the genus Phoradendron is distinguished by bilocular anthers opening separately by longitudinal slits and by flowers arranged on the spikes in several longitudinal rows. Dendrophthora has unilocular anthers opening by a single transverse slit, and the flowers are in a single longitudinal row. Van Tieghem, however, states that the arrangement of flowers may vary. There are pluriseriate Dendrophthoras and possibly uniseriate Phoradendrons. Therefore the structure of the anthers constitutes the real difference between the genera.

Elytranthe globosa Blume. Malay Peninsula.

Loranthus ferrugineus Roxb. Malay Peninsula.

Loranthus pentandrus L. Malay Peninsula.

Oryctanthus botryostachys Eichl. Hermaphroditic; branches erect, fusco-furfuraceous or grayish when old, often terminating in leafless floriferous racemelike extensions; internodes 8 to 12 centimeters long; leaves large, elliptically ovate, tips obtuse or attenuate obtuse, base rounded, yellowish green, young leaves with brown margin and conspicuous fuscous midrib 5 to 16 centimeters long by 4 to 8 centimeters broad; flower spikes solitary in the axils of the leaves or in terminal racemelike combinations, 4 to 6 centimeters long; flowers 15 or more in three to four longitudinal rows, peduncles fuscous, 1 to 1.5 centimeters long; fruit subobovate, yellowish, sometimes purplish at the base. On *Hevea brasiliensis* under *Bixa* sp. at Colonia Pedro Borges, Amazonas. Indigo, *Persea gratissima*, *Bixa orelana*, and *Vernonia* sp. are the common hosts. The species is closely related to *O. amazonicus* Ule, but differs in not being bracteolate.

Phoradendron crassifolium Eichl. Hermaphroditic; branches erect, terete, occasionally pseudodichotomous, yellowish green, glabrous; internodes usually long, 5 to 12 centimeters; bracts or cataphyls on the internodes, subannular, upper ones more or less deciduous and floriferous, rest sterile; leaves large, elliptically ovate, rarely lanceolate, rounded at the base or attenuated along the short petioles, three central nerves usually conspicuous, 4 to 8 or 6 to 10 by 15 centimeters; flower spikes solitary or clustered, axillary or terminal, sometimes compound at the ends of the branches, 3 to 5 centimeters long, with 5 to 7 round fusiform joints usually bearing 8 to 10 flowers in six series; peduncle usually bracteolate at the base, 4 to 5 millimeters long; color of flowers not observed; fruit subglobose, about 4 millimeters in diameter, greenish yellow. On *Hevea brasiliensis* at Riberalta, Bolivia, associated with *Siparuna* sp. and species of Euphorbiaceæ, the most common hosts.

Phthirusa adenostemon Eichl. Monœcious; branches suberect, terete, only slightly compressed in the younger parts, smooth, grayish or greenish gray; internodes 4 to 8 centimeters long; leaves ovate to elliptic, subacuminate, coriaceous, smooth, 5 to 7.5 by 2.5 by 3.5 centimeters, middle nerve prominent, petioles 1 to 1.5 centimeters long; flower spikes solitary or three together in the axils of the leaves, simple or compound, terminal one paniculate, subquadrangular to compressed, 5 to 8 centimeters long, secondary spikes bracteolate at the base; flowers white, two to three on short peduncles, bracteolate, hexagonal and bud shaped when closed, petals six, lanceolate; fruit not observed. Found once on *Hevea brasiliensis* associated with species of Myrtaceæ, the most common host, at Riberalta, Bolivia. The species is also common on *Anahidea* sp. (Bignoniaceæ) and Leguminosæ in the same region.

P. amazonensis Weir, n. sp. Monœcious; branches long radiculate and prehensile, terete, rarely slightly striate, light gray; internodes 4 to 9 centimeters long; leaves thick, coriaceous, smooth, light green, elliptic, acuminate, middle nerve conspicuous, 5 to 9 centimeters long, 3 to 6 centimeters broad; petioles 1 to 1.5 centimeters long; flower spikes solitary in the axils of the leaves, simple, paniculate at the tips of the branches, compressed or subquadrangular, yellowish white, 4 to 9 centimeters long, secondary spikes bractless; flowers 6-parted, red or purplish red, 3 to 4 millimeters long, 1 to 1.5 millimeters broad, cylindrical in outline and obtuse at the top before unfolding; three together, sessile on a short 3-bracteolate peduncle; bracts lanceolate, acuminate; calyx inconspicuous, acute; petals slightly ridged at the base, lanceolate, curved inwardly at the tips; stamens attached to the base of the petals; filaments short, compressed, with conspicuous middle nerve; anthers acuminate, dehiscing by two lateral flaps; style cylindrical, longitudinally striate at the base; stigma capitate-punctate, dark colored; ovary depressed; fruit greenish at base, becoming entirely yellow or only for half of its length, 4 to 5 millimeters long. Found once on *Hevea brasiliensis* associated with species of Bignoniaceæ, Solanaceæ, and Myrtaceæ, the most common hosts, at Riberalta, Rio Beni, Bolivia. Type in United States National Herbarium (No. 1,199,133). This species has the nature of a vine and may extend along and over the branches of the host for considerable distances.

P. brasiliensis Weir, n. sp. Diœcious; branches erect, entirely terete, gray, the last five or six internodes conspicuously ferruginous furfuraceous, with occasional glabrous green areas, the rest smooth; internodes 4 to 5 centimeters long; leaves somewhat fleshy, coriaceous, smooth, deep green, margin brown, ovate to elliptic, acuminate, middle nerve on the

under side with a conspicuous ferruginous-furfuraceous band extending almost its entire length, 6 to 10 centimeters long, 3 to 6 centimeters broad; petioles 0.05 to 1 centimeter long, smooth except for the continuation of the brown band of the nerve; flower spikes solitary, rarely two in the axils of the leaves, simple, slender, terete, ferruginous furfuraceous throughout, 4 to 6 centimeters long; flowers 6-parted, greenish to blood red, 2 to 3 millimeters long, ridged, bud shaped and acute before unfolding, two to three together, sessile on a short 3-bracteolate peduncle, bracts acuminate; calyx inconspicuous, slightly undulate; petals acute; stamens attached to the middle of the petals; filaments short, broad; anthers lobed, acuminate; style corrugated at point of contact with anthers, stigma short; fruit oblong cylindric, green with yellow apex, later reddish orange with yellow tips, 5 to 6 millimeters long. Common on *Hevea brasiliensis* at Urucurituba, Rio Madeira, Democracia, Sao Jose de Amatory, Amazon River, Guajara Mirim, and Rio Mamore. It was also found parasitic on *Dendrophthora poeppigii*, the common leafless mistletoe of Hevea, and on orange and lime growing under Hevea. Type in United States National Herbarium (No. 1,199,132).

P. pyrifolia (H. B. K.) Eich. Monœcious; branches erect, terete, younger parts conspicuously flattened, edges of younger parts and the nodes furfuraceous, ferruginous, the rest glabrous; leaves ovate to oblong lanceolate, rather thick and coriaceous, smooth, distinctly veined, lower part of middle nerve and petiole streaked with brown tomentum; flower spikes solitary in the axils of the leaves, simple terminal ones rarely paniculate, terete to subquadrangular at the base, furfuraceous ferruginous throughout, 4 to 8 centimeters long; flowers small, red or purple-red, three together, sessile or subsessile on short bracteolate peduncles; fruit greenish at base, saffron or lemon yellow at tips, later entirely so, oblong, 5 to 6 millimeters long. Found on *Hevea brasiliensis* at Riberalta, Bolivia. The most common host was *Inga* sp., with which the Hevea tree was closely associated. Also collected on *Mangifera indica*, lime, and cacao. The species is similar to *P. platyciada* Ule, but the flowers of the latter are described as yellowish green.

ALGÆ ON HEVEA

Cephaleuros mycoidea Karst.=presumably *C. virescens* Kunze.

C. virescens Kunze. Thallus of more than one layer of cells attached to the substratum by means of rhizoides, covered with a thin cuticle which ruptures with the development of the sporangia. Sporangiophores variable, numerous, septate, sparingly filled with an orange-colored substance (hematochrome). On leaves, Amazon region. The genus and species were established by Kunze in 1827 in a set of exsiccati and referred to the fungi. His specimens came from Dutch Guiana (Surinam).

C. parasiticus Karst. Thallus, of more than one layer of cells, parasitic in the tissues of the host, developing under the epidermis and invading the mesophyll; sporangiophores variable, numerous, septate, filled with reddish yellow hematochrome. On leaves of *Hevea guyanensis*, Amazon region.

Mycoidea parasitica Cunn. Has been referred to *Cephaleuros virescens* by some authors.

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General view of fungi reported on Hevea and Castilloa, their importance and distribution.

1910. Two interesting fungi in St. Lucia. *In* Agr. News [Barbados], v. 9, p. 286.
Records the occurrence of *Corticium lilacinofuscum* B. and C. on guava in St. Lucia. Possibly identical with *Corticium javanicum*, the cause of the pink disease of Hevea in the Tropics of the East.

1912. Diseases of rubber plants. *In* India-Rubber Jour., v. 43, p. 1154–1155.
Includes a table giving part of plant affected and name of fungi or animal pests.

1914. Leaf disease of Hevea. *In* Planters' Chron., v. 9, p. 272–273.
Dothidelia ulei, Fusicladium macrosporum, and *Passalora heveae* reported on leaves in South America.

1915. [Disease of rubber in British Guiana.] *In* Agr. News [Barbados], v. 14, p. 380.
Mentions an article in the Demerara Daily Chronicle (Mail edition) October 1, 1915, on a serious disease of rubber trees in British Guiana. "The disease appears to be due to *Dothidella ulei.*"

1915. Diseases of Para rubber trees in Ceylon. *In* Agr. News [Barbados], v. 14, p. 303.
Notes on Petch, The fungous diseases of *Hevea brasiliensis,* in Internat. Rubber Cong. and Exhib., Batavia, 1914, Rubber Rec., p. 116–129, 1914.

1915. Root diseases in Malaya. *In* Agr. News [Barbados], v. 14, p. 174–175.
Comment on articles by F. T. Brooks in Agr. Bul. Fed. Malay States, v. 3, p. 40–43, 105–107, 1914. *Sphaerostilbe repens* and *Ustulina zonata* noted as root diseases of Hevea in the Malay States.

1916. Bark rot of Hevea in Burma. *In* India Rubber World, v. 55, p. 105. Also in Trop. Agr., v. 48, p. 12–13, 1917.
Comment on bulletin by Dastur, Burma Dept. Agr. Bul. 14, 1916.

1916. Distribution of pink disease by mukims. *In* Agr. Bul. Fed. Malay States, v. 5, p. 10–13.
Shows locality, intensity, and age of infection. See also revised list by F. W. South in Agr. Bul. Fed. Malay States, v. 6, p. 389–394, 1918.

1917. Enfermedades de los árboles productores de caucho Pará (Hevea brasiliensis). *In* Hacienda, v. 12, p. 205–206, 252–254, illus.
Fungous and insect parasites of Hevea enumerated.

1917. Fighting the leaf disease in Dutch Guiana. *In* India Rubber World, v. 55, p. 297.
Comment on reports of Bancroft and Stahel.

1917. Plantation rubber in British Guiana. *In* India Rubber World, v. 56, p. 552.
Plantations suffer from *Fusicladium macrosporum, Hymenochaete noxia, Thyridaria tarda,* and *Fomes semitostus.*

1917. Rubber in North Borneo. *In* Trop. Agr., v. 49, p. 197–200.
Extract from the Annual report on agriculture in North Borneo for 1916. Most important diseases are *Corticium salmonicolor* and black-thread.

1919. Brown bast on tapped Hevea. *In* India Rubber World, v. 61, p. 54.
Quotes Petch, Rands, Belgrave, Perry, Richards, and Bobilioff. All seem to agree that tapping and the condition of the tree have more to do with the disease than possible infection.

1920. Research on rubber cultivation. *In* Science, v. 51, p. 82–83.
From a correspondent in Sumatra, mainly on a conference on brown bast.

1920. Rubber-tree diseases. *In* India Rubber World, v. 62, p. 612.
Discusses brown bast. Was supposed to be a physiological disease due to tapping; recently, however, a mycologist in Sumatra claims to have isolated a definite bacterium to which the disease is due.

1921. Note [on the 5th International Rubber Exhibition]. *In* Nature [London], v. 107, p. 499.
An important feature of the exhibition was the demonstration of the discovery that brown bast is essentially a question of phloem necrosis.

1921. Pink disease in Malaya. *In* Planters' Chron., v. 16, p. 407–409.
This disease, due to *Corticium salmonicolor,* has been known in the Malay Peninsula since 1912. Control measures discussed.

1922. Root diseases and thinning-out. *In* Malayan Agr. Jour., v. 10, p. 119–121.
High-yielding trees should be examined, since the yield is often due to root disease.

AKERS, C. E.
1912. Report on the Amazon Valley, its rubber industry and other resources. 190 p., illus. London.
General remarks on the pathology of Hevea.
1914. The rubber industry in Brazil and the Orient. 320 p., illus. London.
Chapter IV. Diseases and pests common to rubber trees in Brazil. General descriptions, using popular names of diseases only. Diseases briefly mentioned in chapters on the Orient.

AMIN, M.
1920. Mouldy rot (disease of recently tapped bark). *In* Agr. Bul. Fed. Malay States, v. 8, p. 174–175.
Attacks the renewing bark about 1 inch above and parallel to the tapping cut. The causal fungus is a species of Sphaeronema.

ANSTEAD, R. D.
1910. Canker on Para rubber. *In* Planters' Chron., v. 5, p. 516.
Canker on the tapping cut; South India.
1910. Diseases of Para rubber. *In* Planters' Chron., v. 5, p. 140.
Pink disease (*Corticium javanicum*) and die-back, caused by *Gloeosporium alborubrum* and *Botryodiplodia theobromae*.
1910. Pink disease of Para rubber and Bordeaux mixture. *In* Planters' Chron., v. 5, p. 210–212. Also in Trop. Agr. v. 34, p. 565, 1910.
1910. Report on a tour in Cochin and Travancore. *In* Planters' Chron., v. 5, p. 174–177.
Pink disease and die-back were found. Report is largely quoted from Circ. Roy. Bot. Gard., Ceylon, v. 4, nos. 21 and 23, by Petch. Portion about pink disease reprinted in Trop. Agr., v. 34, p. 475–476.
1910. Second tour in Cochin. *In* Planters' Chron., v. 5, p. 501–502.
Report on experiments in prevention of pink disease. Extract in Agr. Bul. Straits and Fed. Malay States, v. 10, p. 6–7, 1911; and Trop. Agr., v. 35, p. 463, 1910.
1910. Root disease of Hevea. *In* Planters' Chron., v. 5, p. 546.
Hymenochaete noxia appears to be the most common root fungus in southern India. *Fomes semitostus* and *Sphaerostilbe repens* are also found.
1911. Pads formed on Hevea trees. *In* Planters' Chron., v. 6, p. 2–4.
Quotes Petch (Trop. Agr., July and Aug., 1909) at some length.
1911. Pink disease of Para rubber and Bordeaux mixture. *In* Planters' Chron., v. 6, p. 98–101.
Recommendations for control and directions for mixing solutions.
1911. Report on a tour in Cochin and South Travancore. *In* Planters' Chron., v. 6, p. 282–284.
Die-back (Gloeosporium and Botryodiplodia) and pink disease of rubber noted.
1911. Second tour in the Anamalais. *In* Planters' Chron., v. 6, p. 88–90.
Pink disease of Hevea mentioned.
1914. Nodules on Hevea rubber trees. *In* Planters' Chron., v. 9, p. 14–15.
1916. Bark rot of Hevea. *In* Planters' Chron., v. 11, p. 382–383.
Comment on bulletin by Dastur, Burma Dept. Agr. Bul. 14, 1916.
1916. Fungoid diseases of Hevea rubber. *In* Planters' Chron., v. 11, p. 522–523.
Comment on article by Petch published in Times of Ceylon.
1916. Rubber Growers' Association of Southern India. (Report of meeting.) *In* Planters' Chron., v. 11, p. 628–630.
Discussion of pink disease and its treatment and of abnormal leaf fall.
1917. Abnormal leaf fall of Hevea rubber. *In* Planters' Chron., v. 12, p. 54–56.
Recommendations for control.
1917. Abnormal leaf fall of rubber. *In* Planters' Chron., v. 12, p. 264.
1917. Bark rot of rubber. *In* Planters' Chron., v. 12, p. 582.
Disease worst in sections where trees had not been thinned out.
1917. Black-thread disease of Hevea. *In* Planters' Chron., v. 12, p. 571–572.
Quotes Ann. Rpt. Agr. North Borneo for 1916. Disease caused by Phytophthora.
1918. Mouldy rubber. *In* Planters' Chron., v. 13, p. 703–704.
1918. The treatment of fungoid diseases on estates. *In* Agr. Jour. India, v. 13, p. 95–104.
Lecture delivered at the annual meeting of the United Planters' Association of Southern India, 1917.
1919. Brown bast of Hevea rubber. *In* Planters' Chron., v. 14, p. 320–324.
Lecture delivered at a meeting of the South Indian branch of the Rubber Growers' Association held at Cochin, May 17, 1919.
1919. Hevea leaf-disease in Surinam. *In* Planters' Chron., v. 14, p. 453.
South American leaf disease, caused by *Fusicladium macrosporum*, in Surinam, British Guiana, and Brazil.
1919. Mr. Anstead's tour. *In* Planters' Chron., v. 14, p. 708–710, 784–790, 840–843, 879–880.
Different parts deal with abnormal leaf fall due to *Phytophthora meadii*, moldy rubber, and brown-bast.
1920. Brown bast. *In* Planters' Chron., v. 15, p. 294–297.
Analysis of a paper by J. R. Harmsen, a translation of which appeared in the Malayan Tin and Rubber Jour., October 31, 1919.

ANSTEAD, R. D.—Continued.
1920. Rubber in South Travancore. *In* Planters' Chron., v. 15, p. 324–325.
Three to four per cent of brown-bast was found. Bark-rot (*Phytophthora meadii*) and abnormal leaf-fall were important diseases.

ARDEN, S.
1904. L'Hévéa brasiliensis dans la Péninsule Malaise. 70 p., illus. Paris.
Helicobasidium sp. the only fungus mentioned, p. 19–22.

ARENS, P.
1912. Bacterium prodigiosum (Ehrenb.) Lehm. et Neum. als Erreger der roten Flecken auf frisch bereitetem Kautschuk. *In* Centbl. Bakt., Abt. 2, Bd. 35, p. 465–466.

1914. Schimmels en bakterien op bereide rubber. *In* Internat. Rubber Cong. and Exhib. Batavia, 1914, Rubber Rec., p. 397–400. German translation, p. 399–400.

[1916.] Abnormale bladafval bij Hevea. *In* Meded. Proefstat. Malang, no. 14, p. 6–11.

1918. Een nieuwe bladziekte van Hevea, veroorzaakt door een meeldauwschimmel (Oidium spec.). *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 2, p. 827–835. (Meded. Proefstat. Malang, no. 24.)
English summary: A new leaf disease of Hevea caused by a mildew (*Oidium* sp.), p. 834–835.

1918–20. Werkzaamheden in het belang van de rubbercultuur. A. Verslag van den plantkundige, 1918–1920. *In* Java (Middle) Proefstat. Malang, Verslag Omtrent Werkzaamheden. 1918, p. 5–8; 1919, p. 5–10; 1920, p. 4–9. (Verslag 1918 and 1920 are Meded. Proefstat. Malang, no. 27 and 34.)
See also 1922 by W. Bally.

ASHBY, S. F.
1921. Root diseases and brown bast of Para rubber in the East. *In* Agr. News [Barbados], v. 20, p. 270.
Summary of articles by Sanderson and by Farmer and Horne in India-Rubber Jour., v. 61, p. 1225–1226, 1227–1228, 1921.

ASHPLANT, H.
1921. Para rubber. Dept. Agr. Uganda Circ. 6, p. 31.
"Pests and diseases," p. 13–16. "All the well-known stem diseases of Hevea are in evidence in Uganda. Two of the most troublesome affections—stripe canker and brown bast—are particularly bad."

1922. The diseases of rubber. *In* Planters' Chron., v. 17, p. 57–60.
Extracts from monthly reports (Nov. and Dec., 1921) of rubber mycologist. Die-back (phytophthora), brown-bast, and patch canker discussed.

1922. Extract from report of rubber mycologist. *In* Planters' Chron., v. 17, p. 263–266.
Treats of secondary leaf-fall of Hevea; inoculation experiments and disease-resistant trees.

1922. Extracts from reports of rubber mycologist from March–June, 1922. *In* Planters' Chron., v. 17, p. 456–458.
Experimental work on secondary leaf disease.

1925. Brown bast—an inquiry into the Keuchenius treatment. *In* Trop. Agr., v. 64, p. 334–343.
Taken from his Recent developments in the rubber planting industry with special reference to budding, brown-bast treatment, manuring of rubber, etc.

1925. Thinning out of rubber. (Abstract.) *In* India-Rubber Jour., v. 69, no. 7, p. 17–18.
Impracticable in India and Ceylon, but recognized as necessary in many regions to prevent deterioration of the stand.

1925. Rubber crop losses during the wet months. *In* India-Rubber Jour., v. 69, no. 15, p. 13–14.

ASSOCIATION DES PLANTEURS DE CAOUTCHOUC.
1921. Les maladies de l'Hévéa. *In* Bul. Assoc. Plant. Caoutchouc, v. 9, p. 7–8.
Black-stripe canker and moldy rot described.

AUCHINLECK, G. G.
1913. Note on the present position of rubber in Grenada. *In* West Indian Bul., v. 13, p. 264–267.
Hevea has been quite free from disease. Castilloa has been attacked by a fungus which appears on the stem at the ground line and destroys the bark, probably a Rosellinia.

BAKER, C. A.
1910. Instructions to managers and assistants on rubber estates. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 369–380.
Tree sanitation, p. 371–377. Trees are to be inspected for following diseases: *Termes gastroi, Fomes semitostus, Diplodia rapax*. Symptoms and treatment are given.

BAKER, C. F.
1914. The lower fungi of the Philippine Islands. A bibliographic list chronologically arranged and with localities and hosts. *In* Leafl. Philippine Bot., v. 6, p. 2065–2190.
Includes *Lasiodiplodia theobromae* on Hevea, p. 2151.

1919. Fungi from Singapore and also from Penang. *In* Gard. Bul. Straits Settlements, v. 2, p. 116–120.
List of fungi collected by Baker and enumerated by Saccardo in Bul. Ort. Bot. Napoli, tomo 6, p. 39–73, 1921.

BAKER, C. F.—Continued.
1919. Hevea versus fungi. *In* Gard. Bul. Straits Settlements, v. 2, p. 109–113.
Stresses the importance of knowing every fungus growing on or in connection with rubber trees. Lists 10 new species and 1 new genus found at Singapore.

BALLOU, H. A.
1913. Report on the prevalence of some pests and diseases in the West Indies, 1912. *In* West Indian Bul., v. 13, p. 333–357.
Pt. II. Fungus diseases, p. 341–345. Only fungous disease reported on rubber is black root, in Grenada. See also reports for 1909–10 and 1910–11 by F. W. South; 1913– by W. Nowell.

BALLY, W.
1920. Mouldy rot. *In* Arch. Rubbercult. Nederland-Indie, jaarg. 4, Alg. Gedeelte, p. A295–A299, illus. (Meded. Proefstat. Midden-Java.)

1922. Werkzaamheden in het belang van de rubbercultuur. A. Verslag van den plantkundige. *In* Java (Middle) Proefstat. Malang, Verslag Omtrent Werkzaamheden, 1922, p. 6–10. (Meded. Proefstat. Malang, no. 42.) See also 1918–1920 by P. Arens.

BANCROFT, C. K.
1910. A handbook of the fungus diseases of West Indian plants. 70 p., illus. London.
Mentions 17 fungi found on *Hevea brasiliensis*, with descriptions of some.

1910. A preliminary note on the fungus causing the "die-back" disease of cacao and of Para rubber. *In* Agr. Bul. Straits and Fed. Malay States., v. 9, p. 475–478.
Thyridaria tarda is the cause of die-back. It is a wound parasite, and the disease is caused by the fungus when it is in its Diplodia stage. The Diplodia condition is capable of reproducing itself and passes on the dead parts into the ascigerous (Thyridaria) condition some time after they are dead.

1911. Brown root disease of Para rubber (Hymenochaete noxia). *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 106–108.
Found on many different hosts in most of the tropical countries. Grows slowly and seldom fruits on Malay Peninsula.

1911. The die-back fungus of Para rubber and of cacao. (Thyridaria tarda n. sp.). Dept. Agr. Fed. Malay States Bul. 9, 28 p., illus.
The fungus is a wound parasite and the disease is caused by the Diplodia stage. The ascigerous form is *Thyridaria tarda*, of which the two pycnidial forms, Diplodia and Cytospora, are stages.

1911. The die-back disease of Para rubber and a note on the leaf diseases of Para rubber. Dept. Agr. Fed. Malay States Bul. 14, 23 p., illus.
A less technical account of the disease caused by *Thyridaria tarda* than that in Dept. Agr. Fed. Malay States Bul. 9 mentioned above.

1911. A note on the canker of Hevea brasiliensis. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 203–208. Also in Planters' Chron., v. 6, p. 583–586. 1911.
Canker has not yet been recorded in Malay States. Describes diseases caused by *Nectria diversispora* and *Stilbella hevecae*.

1911. Report of the mycologist for the year 1910. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 244–250.
Treats of *Fomes semitostus, Hymenochaete noxia, Thyridaria tarda, Corticium javanicum*, thread-blight, *Pestalozzia guepini*, and burs. Diseases of Para rubber, p. 245–248; diseases of Ceara rubber, p. 250.

1911. On the occurrence and nature of spots on Para sheet and crêpe; a preliminary note. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 318–320.
Attributes discolorations to the mycelium of fungi. So far no chromogenic bacilli have been observed in the spotted rubber on Malay Peninsula.

1911. The occurrence of burrs on the trunk of Hevea brasiliensis. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 138–141.
Burs are of two types: One occurs on untapped as well as tapped trees, the other is the result of wounding; common on Malay Peninsula on all soils.

1911. A thread blight on Para rubber, camphor, etc. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 110–114, illus.
"Clamp-connexions can be frequently found in the mycelium on the leaves . . . From the presence of these organs the fungus is concluded to be a Basidiomycete. From what is known of mycelium of this nature, one might expect the fungus to belong either to the genus Hypochnus or to the genus Corticium."

1912. A note on the hosts which afford a starting point for the common root disease of Para rubber. *In* Agr. Bul. Fed. Malay States, v. 1, p. 141–143.
"*Fomes semitostus* in Malaya . . . has been recorded on members of the two main groups of flowering plants, the Monocotyledones and Dicotyledones, and on widely separated representatives of each group."

1912. Notes on investigations of plant diseases in the Federated Malay States during 1911. *In* Agr. Bul. Fed. Malay States, v. 1, p. 24–31; 2, p. 27–34.
First two numbers treat of rubber diseases; later numbers devoted to other plants.

BANCROFT, C. K.—Continued.

1912. A root disease of the Para rubber tree. (Fomes semitostus Berk.) Dept. Agr. Fed. Malay States Bul. 13, 30 p., illus.
Found in the Federated Malay States, Ceylon, southern India, Java, Gold Coast, and Belgian Congo. On many different hosts. Other root fungi mentioned are *Hymenochaete noxia, Helicobasidium mompa,* and *Irpex flavus.*

1913. A list of fungi identified in the Federated Malay States, with notes on their occurrence. *In* Agr. Bul. Fed. Malay States, v. 1, p. 259–264.
Lists 19 fungi found on Hevea, 3 on prepared rubber, and 1 on Manihot, without descriptions.

1913. Miscellaneous botanical notes. *In* Agr. Bul. Fed. Malay States, v. 1, p. 218–221.
Cost of treatment of pink disease; distribution of the brown-root fungus; spread of *Fomes semitostus* by wash; disease of Hevea caused by *Phyllosticta ramicola.*

1913. The spotting of plantation Para rubber. (A preliminary account of investigations on the cause of the spotting.) Dept. Agr. Fed. Malay States Bul. 16, 30 p., illus.
An account of experiments in which *Monascus heterosporus, Spondylocadium maculans, Mycogone* sp., and other organisms were isolated from spotted rubber.

1915. Report on the Botanic Gardens and their work. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana 1913–14, appendix 2, 25 p.
Several fungi noted on Hevea.

1916. Report on the Botanic Gardens and their work. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana, 1915, appendix 2, 12 p.
Mentions leaf disease of Para rubber as prevalent and causing considerable damage.

1916. Report on the Botanic Gardens and their work. *In* Rpt. Dept. Sci. and Agr. British Guiana, 1915, appendix 2, 12 p.
Several fungi reported on Hevea. *Fusicladium macrosporum,* first recorded in 1909, now occurs in all parts of the colony. *Fomes semitostus* reported for the first time on cultivated Hevea.

1916. Report on the South American leaf disease of the Para rubber tree. *In* Jour. Bd. Agr. Brit. Guiana, v. 10, p. 13–33.
The leaf disease is caused by a fungus, *Fusicladium macrosporum,* which is propagated by spores of three forms.

1917. The leaf disease of rubber. Conditions in Surinam. *In* Jour. Bd. Agr. Brit. Guiana, v. 10, p. 93–103.
Treats of the South American leaf disease, caused by *Fusicladium macrosporum.*

1917. Report on the Botanic Gardens. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana, 1916, p. 53–56.
Report on the progress of the leaf disease, which is diminishing but still causing much damage at Christianburg and Wismar.

1918. Disease in plants, with special reference to fungi parasitic on crops in British Guiana. *In* Jour. Bd. Agr. Brit. Guiana, v. 11, p. 47–57.
Mentions *Melanopsammopsis ulei* on Hevea.

1919. Report on the Botanic Gardens. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana, 1917, p. 45–52.
Report on *Melanopsammopsis ulei.* Not so prevalent as in the previous year. Indigenous rubber plants (*Hevea confusa*) in forests spread infection.

BARRETT, O. W.

1911. Warnings to rubber planters. *In* Philippine Agr. Rev., v. 4, p. 647–648.
Possibility of introducing diseases of Hevea into the Philippine Islands from the Federated Malay States and Ceylon.

BATESON, E.

1911. Loranthus as a parasite on Hevea brasiliensis. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 360–361.
Loranthus is closely related to the European mistletoe. It enfeebles the branch on which it grows and may allow the entrance of fungi.

1913. Bark-canker of Hevea in Java. *In* Agr. Bul. Fed. Malay States, v. 1, p. 299–301.
Largely comment on Rutgers, Hevea-kanker, in Meded. Inst. Plantenziekten Buitenzorg, No. 2, 1912. Bark canker (*Phytophthora faberi*) has not yet been recorded from the Federated Malay States.

1913. Burr formation: A preliminary note. *In* Agr. Bul. Fed. Malay States, v. 1, p. 446–449; 2, p. 24.
Advances theory that most nodules being found on leaf scars, they may be caused by decomposition of vascular tissue left in the cortex when the leaf falls.

1913. A note on the possible occurrence of a bacterial disease of Hevea. *In* Agr. Bul. Fed. Malay States, v. 1, p. 268–270.
Wood of diseased specimen discolored to a depth of an inch; vessels filled with bacteria embedded in mucilaginous substance. Cultures were made and infection of healthy specimens attempted. Experiments gave negative results.

1914. The tapping of the Para rubber tree. Some physiological experiments. Bul. Dept. Agr. Fed. Malay States 23, 54 p., illus.
Bur formation, p. 43–48.

BAVAY, Y. DE.
1918. Rapport sur la plantation à Hévéas de Yangambi (Stanleyville). *In* Bul. Agr. Congo Belg., v. 9, p. 78–94, illus.
Maladies des Hévéas, p. 92 (*Fomes semitostus*).

BEELI, H.
1922. Énumération des champignons signalés au Congo Belge. In Bul. Jard. Bot. Etat, Bruxelles, v. 8, p. 67–101.
Includes species recorded on Hevea.

BELGRAVE, W. N. C.
1915. [Review of] the diseases of tropical plants, by M. T. Cook. *In* Agr. Bul. Fed. Malay States, v. 4, p. 21–22.
Disagrees with Cook's statements about canker and pink disease.

1916. A root disease of plantation rubber in Malaya due to Poria hypolateritia (Berk). (Preliminary report.) *In* Agr. Bul. Fed. Malay States, v. 4, p. 347–350. Extracts in India-Rubber Jour., v. 52, p. 792, 1916.
Attacks old trees, spreading by contact of diseased roots. Wet-rot. Ceylon and Federated Malay States.

1917. Experiments on the prevention of brown bast. *In* Agr. Bul. Fed. Malay States, v. 6, p. 187.
Suggestions for soil treatment.

1917. Further notes on black-stripe canker. *In* Agr. Bul. Fed. Malay States, v. 6, p. 154–155.
Notes on treatment of canker and on sterilization of tapping knives.

1917. A preliminary note on "brown bast." *In* Agr. Bul. Fed. Malay States, v. 6, p. 1.
Disease attributed to a new species of Spongospora, but note states that further work makes it seem possible that the organism may eventually be identified as one of the lower forms of algæ.

1917. Root diseases of Hevea and clean clearing. *In* Agr. Bul. Fed. Malay States, v. 5, p. 318–326. Also in Proc. 1st Agr. Conf., Malaya, 1917, p. 55–63, 1917.
Fungous root diseases known to attack Hevea on the Malay Peninsula are: *Fomes lignosus, Sphaerostilbe repens, Ustulina zonata, Poria hypolateritia, Hymenochaete noxia.*

1919. Notes on mycology during 1918. *In* Agr. Bul. Fed. Malay States, v. 7, p. 141–143.
Reports on brown-bast, black-stripe, moldy rot, Cladosporium, branch, leaf, and pod diseases, and root and collar diseases. Paragraphs on brown-bast and black-stripe reprinted in Planters' Chron., v. 14, p. 851, 1919.

1919. A wet-rot of Para rubber roots. Bul. Dept. Agr. Fed. Malay States 28, 21 p., illus. References, p. 19.
Caused by *Fomes pseudoferreus* (Wakefield), previously described as *Poria hypolateritia*. Field observations, growth in pure culture, inoculation experiments, treatment, and prevention.

1921. Notes on the "South American leaf disease" of rubber. *In* Agr. Bul. Fed. Malay States, v. 9, p. 179–183. Also in Trop. Agr. v. 59, p. 109–113, 1921; and Jour. Bd. Agr. Brit. Guiana, v. 15, p. 132–138, 1922.
Disease first attributed to *Fusicladium macrosporum*, later to *Passalora heveae*, and finally to *Melanopsammopsis ulei*. In Trinidad and British Guiana. Not yet found on Malay Peninsula.

——— and NORRIS, F. DE LA M.
1917. Notes on bark cankers and their treatment. *In* Agr. Bul. Fed. Malay States, v. 6, p. 2–10.
States that bark disease on Malay Peninsula is increasing. Considers following diseases: Claret-colored or bark canker; black-stripe canker; moldy rot of recently tapped surface and water-logged bark, or brown-bast.

——— and SOUTH, F. W.
1918. Field notes and observations on brown bast. *In* Agr. Bul. Fed. Malay States, v. 6, p. 181–186. Also in Trop. Agr., v. 50, p. 286–290, 1918.
"The fact that this disease may make its appearance at either of two different and definite places on a tree, the collar or the tapping cut, appears to the writers a strong indication that it is caused by a definite organic parasite."

BERNARD, C.
1906. Eene ziekte van Hevea, veroorzaakt door de djamoer oepas (Corticium javanicum Zimm.). *In* Teysmannia, jaarg. 17, p. 318–320.
Pink disease, formerly known on coffee, etc., now found on Hevea in Sumatra.

1906. Waarnemingen en onderzoekingen op plantkundig gebied en hare toepassingen. Botanische Laboratoria. *In* Verslag Dept. Landb. Buitenzorg, 1905, p. 23–27.
Corticium javanicum reported on *Hevea brasiliensis*.

1907. Notes de pathologie végétale. I–III. Bul. Dept. Agr. Indes Néerland. 6, 11, 12, illus.
Contents: I. Sur quelques maladies de *Thea assamica*, de *Kickxia elastica* et de *Hevea brasiliensis*. II. Sur quelques maladies de *Citrus* sp., *Castilloa elastica, Thea assamica*, &c. III. Sur quelques maladies des plantes à caoutchouc. Summary of part 3 in Agr. Bul. Straits and Fed. Malay States, v. 7, p. 169–173, 439–443, 1908.

BERTRAND, H. W. R.
1924. Phytophthora leaf-fall of rubber. *In* Trop. Agr., v. 62, p. 144–146.
"The various forms of Phytophthora are, in the writer's opinion, responsible for more damage to estates than all the other diseases put together."

BETCHE, E.
1909. A parasitic disease which kills cocoa and rubber trees. *In* Trop. Agr., v. 32, p. 502.
Hymenochaete noxia, reported from Samoa. See also Ridley, Another fungus parasite on rubber, in Agr. Bul. Straits and Fed. Malay States, v. 8, p. 312, 1909.

BIRKINSHAW, F.
1923. Cover crops and the spread of Fomes lignosus. *In* Malayan Agr. Jour., v. 11, p. 216. Also in Trop. Agr., v. 61, p. 296–297, 1923.
Fungus spreads more rapidly on cover crops than on clean weeded land.

BISHOP, R. O., and GREENSTREET, V. R.
1923. Dichlorhydroquinone as a preventative of spot disease on rubber. *In* Malayan Agr. Jour., v. 11, p. 129–131.
Experiments with a commercial preparation for the prevention of mold on prepared rubber.

BLOMMENDAAL, H. N.
1921. Het optreden van witte vlekken op crepe. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5. p. 361–366. (Meded. Alg. Proefstat. A. V. R. O. S. Rubberserie no. 33.)
Report on experiments with bacteria causing spotting of prepared rubber.

BOBILIOFF, W.
1919. Over de oorzaak der bruine binnenbastziekte van Hevea brasiliensis. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 3, p. 172–178. (Meded. Physiologiefonds.)
English summary, The cause of brown-bast of *Hevea brasiliensis*, p. 178. The cause of brown-bast is physiological, and the severity of the disease probably depends upon the general physiological conditions of the trees.

1921. Over het uitdunnen en het optreden van bruine-binnenbastziekte bij Hevea. *In* Teysmannia, jaarg. 32, p. 141–142.
Summary of article by Harmsen in Nederland.-Ind. Rubbertijdschr., jaarg. 5, 2 de halfjaar, p. 745, 1921.

1924. Over een geval van degeneratie der melksapvaten van Hevea. (With summary: On a case of degeneration of latex vessels in Hevea.) *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 8, p. 861–868, illus.

BR., L.
1909. Maladie des racines de l'Hévéa. *In* Jour. Agr. Trop., ann. 9, p. 48.
Review of articles by Bernard, Gallagher, and Petch on Hevea root diseases.

BRICK, C.
1909. Einige Krankheiten und Schädigungen tropischer Kulturpflanzen. *In* Jahresber. Angew. Bot., jahrg. 6 (1908), p. 223–258, illus. Also in Ber. Stat. Pflanzenschutz Hamburg 10 (1907/08), p. 223–258, 1909.
"Kautschukbäume," p. 244–253. *Lasiodiplodia nigra* on *Hevea brasiliensis* from Ceylon; *Hymenochaete noxia* on *Castilloa elastica* in Samoa.

BROOKS, F. T.
1914. A new disease of plantation rubber in Malaya. *In* Agr. Bul. Fed. Malay States, v. 3, p. 105–107.
"The fungus is evidently one of the Xylariaceae and appears to be similar to and possibly identical with *Ustulina zonata*." Affects collar and neighboring roots.

1914. Parasitic flowering plants on rubber trees. *In* Agr. Bul. Fed. Malay States, v. 2, p. 165–166.
Later identified as species of Loranthus; see his Species of Loranthus on rubber trees, in Agr. Bul. Fed. Malay States, v. 3, p. 7–9, 1914.

1914. Pink disease. *In* Agr. Bul. Fed. Malay States, v. 2, p. 238–242.
Caused by *Corticium salmonicolor* or *C. javanicum*. Recorded on Para rubber in Java, Borneo, Sumatra, Ceylon, Burma, and southern India as well as on Malay Peninsula. On a great variety of other hosts including native plants, from which it probably has spread to cultivated plants.

1914. Root disease of Para rubber caused by Sphaerostilbe repens. *In* Agr. Bul. Fed. Malay States, v. 3, p. 40–43.
Sometimes lives solely as a saprophyte, but the author has found it advancing into living tissues and therefore acting as a parasite.

1914. Species of Loranthus on rubber trees. *In* Agr. Bul. Fed. Malay States, v. 3, p. 7–9.
Semiparasitic mistletoes reported from Negri Sembilan.

1915. A disease of plantation rubber caused by Ustulina zonata. *In* New Phytol., v. 14, p. 152–164, illus. References, p. 164.
Not previously recorded on Malay Peninsula. The disease chiefly affects the collar and root systems of old rubber trees.

1915. A disease of plantation rubber caused by Ustulina zonata. Bul. Dept. Agr. Fed. Malay States 22, 11 p., illus.
Chiefly affects the collar and root system of old rubber trees. Found in Ceylon and on Malay Peninsula.

BROOKS, F. T.—Continued.

1916. Observations on some diseases of plantation rubber in Malaya. *In* Ann. Appl. Biol., v. 2, p. 209–227, illus. Bibliography, p. 226–227. Review in Planters' Chron., v. 12, p. 6–7, 1917.
Discusses 13 of the better known diseases of rubber, but considers none of them serious as yet on Malay Peninsula.

——— and SHARPLES, A.

1914. Pink disease. Bul. Dept. Agr. Fed. Malay States 21, 27 p., illus. References, p. 25–26.
Distribution, hosts, and mode of action are described. The fungus is not a typical Corticium, and the pink incrustation is usually sterile. Affects the wood as well as the bark of rubber trees.

1915. Pink disease of plantation rubber. *In* Ann. Appl. Biol., v. 2, p. 58–80, illus. Bibliography, p. 80.
Caused by *Corticium salmonicolor* (same as *Corticium javanicum*); most serious rubber disease found on Malay Peninsula. Occurs also in North Borneo, Ceylon, India, and Sumatra.

BROWN BAST INVESTIGATION COMMITTEE. FEDERATED MALAY STATES.

1919. Brown bast. The treatment of affected Hevea trees. Views of Malaya's Investigation Committee. *In* Trop. Agr., v. 53, p. 192–196. Reprinted from Malayan Tin and Rubber Journal, v. 8, no. 13.
"Sections I and II have been prepared by Mr. H. C. Pinching; section III by Mr. G. E. Perry; the whole has been edited by Mr. R. M. Richards."

BRYCE, G.

1911. Notes sur les maladies de l'Hévéa. *In* Bul. Agr. Congo Belg., v. 2, p. 257–267, illus.
Abnormal growths, bark disease (*Corticium javanicum*), die-back (Gloeosporium and Botryodiplodia) and leaf-fall included.

1915. Abstract from report of . . . acting botanist and mycologist. Rpt. Dept. Agr. Ceylon, 1915, p. 11.
Records a pod disease and leaf-fall caused by *Phytophthora faberi* and a root disease of young rubber caused by *Poria hypolateritia*, also an outbreak of bark rot. See also full report in Trop. Agr., v. 47, p. 29–35, 145–146, 1916.

1916. Diseases of Hevea brasiliensis. Bul. Dept. Agr. Ceylon 29, 10 p. Also in Trop. Agr., v. 48, p. 82–89, 1917.
Fomes lignosus, Hymenochaete noxia, Ustulina zonata, Poria hypobrunnea, pink disease, die-back, Phytophthora diseases.

1916. On the formation of nodules in the cortex of Hevea brasiliensis. Bul. Dept. Agr. Ceylon 28, 23 p. Abstract in Planters' Chron., v. 11, p. 608.
Produced as the result of alteration in latex-vessel content; not connected with attack of any parasitic organism. Four types of nodule distinguished. Occur on Hevea in Brazil and in tropical America and the eastern Tropics. Tapping appears to induce nodule formation in predisposed trees.

1916. Report of the acting botanist and mycologist. (1915.) *In* Trop. Agr., v. 47, p. 29–35, 145–146.
Hevea, p. 29–30. *Phytophthora faberi, Fomes lignosus*, bark rot, *Poria hypolateritia*, and *Colletotrichum ficus*. See also summary of this report in Ceylon Dept. Agr. Rpt. 1915, p. 11.

1917. On the formation of nodules in the cortex of Hevea brasiliensis Muell.-Arg. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 6, p. 257–290. References, p. 289–290.
Nodules produced by alteration in the latex-vessel content; not connected with attack of any parasitic organism; do not occur on untapped trees.

1920. Loranthus eradication. *In* Trop. Agr., v. 55, p. 108–109. (Ceylon Dept. Agr. Leaflet No. 15.)
Among economic crops it is found on cacao and occasionally on Hevea.

1920. Report on the work of the botanical and mycological division. Rpt. Dept. Agr. Ceylon, 1920, p. 13–15. Also in Trop. Agr., v. 56, p. 144–146, 1921.
Reports brown-bast less prevalent; Fomes and brown-rot disease especially frequent; other diseases less serious.

1921. Brown bast and the rubber plant. *In* Nature (London), v. 108, p. 81–82.
Criticism of Note in Nature, v. 107, p. 499, 1921.

1923. Globular shoots and nodules in Hevea cortex. *In* Trop. Agr., v. 60, p. 97–99, illus.
Globular shoots are derived from latent buds. Nodules are of several types and from different causes.

1923. The toxic effect of lime on Fomes lignosus Klotzsch. *In* Trop. Agr., v. 60, p. 101–102.

1923. The toxicity of lime to Fomes lignosus Klotzsch. Bul. Dept. Agr. Ceylon 64, 17 p.
"It is considered that soil applications of burnt lime are of little fungicidal value for *Fomes lignosus*."

BUNTING, R. H.

1915–19. Report of the mycologist. *In* Rpt. Dept. Agr. Gold Coast, 1915, p. 21–25; 1916, p. 20–22; 1917, p. 19–21; 1918, p. 22–24; 1919, p. 20–21.
No report on mycology published in 1920; report for 1919 contains nothing on rubber diseases. For later reports see Bunting, R. H., Report of the Research branch, 1921 to date.

BUNTING, R. H.—Continued.
1921. Report of the Research branch, 1921. *In* Rpt. Dept. Agr. Gold Coast, 1921, p. 23–26.
For earlier reports see Bunting, R. H. Report of the mycologist, 1915–1919.

BUSSE, K.
1907. Krebskrankheit der Hevea. *In* Tropenpflanzer, jahrg. 11, p. 792–793.
Control measures discussed. Abstract by W. J. Gallagher in Agr. Bul. Straits and Fed. Malay States, v. 7, p. 15, 1908.

BUTLER, E. J.
1906. Diseases of rubber trees. *In* Agr. Jour. India, v. 1, p. 260–261.
Notes on canker (Nectria) of *Hevea brasiliensis* and Diplodia on *Castilloa elastica*.
1917. Botany, part 3, mycology. *In* Ann. Rpt. Bd. Sci. Advice, India, 1915–16, p. 103–113.
Black-thread of rubber (*Phytophthora faberi*).
1918. Fungi and disease in plants; an introduction to the diseases of field and plantation crops, especially those of India and the East. 547 p., illus. Calcutta and Simla. Bibliography, p. 518–531 (Rubber, p. 531).
Chapter on rubber, p. 490–516. Discusses pod-rot and canker, black-thread and leaf-fall, pink disease, brown-root disease, die-back, anthracnose, Hevea leaf-spot, and Ceara leaf-spot.
1918. Immunity and disease in plants. *In* Agr. Jour. India, v. 13 (suppl.), p. 10–28. Extract in Planters' Chron., v. 14, p. 149–152, 1919.
In pink disease of rubber the attack is often most marked on the shady side because of thinner bark.

CAMERON, A.
1907. Canker in Para rubber trees. *In* Trop. Agr., v. 28, p. 412–413.
A letter inquiring about symptoms, treatment, etc., and giving experience. For reply see Petch, Canker in Para rubber trees, in Indian Agr., v. 32, p. 190, 1907.

CARMENT, A. G.
1921. A bacterial disease of rubber trees. Circ. Dept. Agr. Fiji Isl., v. 2, p. 46.
Bacteria were cultured; organism was a short rod, motile, and with no evidence of spore formation. See also Simmonds, A bacterial disease of Para rubber, in Circ. Dept. Agr. Fiji Isl., v. 2, p. 45.

CARRUTHERS, J. B.
1900–04. Report of the government mycologist and assistant director. *In* Rpt. Dir. Roy. Bot. Gard. Ceylon, 1900, p. 4–7; 1901, p. 5; 1902, p. 11; 1903, p. 5–10; 1904, p. 5–6.
Title varies slightly. Reports for 1901 and 1902 do not mention rubber diseases. Fuller report for 1901 in Peradeniya, Roy. Bot. Gard. Circ. and Agr. Jour., v. 2, p. 1–21, 1902. Reports for 1903 and 1904 are reprinted in same, v. 2, p. 217–233, 1904, and v. 3, p. 95–100, 1905. 1903 is reprinted also in Trop. Agr., v. 24, 1904/05, suppl. See also report of the government mycologist, 1905–09, by Petch.
1902–05. Report of the government mycologist and assistant director, 1901, 1903, 1904. *In* Circs. and Agr. Jour. Roy. Bot. Gard. Ceylon, v. 2, p. 1–21, 217–233; 3, p. 95–100.
Report for 1901 is fuller than that included in the report of the director. 1903 and 1904 are reprints.
1903. The canker fungus in rubber. *In* Agr. Bul. Straits and Fed. Malay States, v. 2, p. 389–392. Also in Trop. Agr., v. 23, p. 372–373, 1903.
Lecture to Kalutara Planters' Association, Teluwana, Ceylon. Reprinted from Overland Times of Ceylon, November 2, 1903. Disease first noticed in 1901; reported to government mycologist in 1903. Caused by a species of Nectria.
1905. Canker (Nectria) of Para rubber (Hevea brasiliensis). *In* Circs. and Agr. Jour. Roy. Bot. Gard., Ceylon, v. 2, p. 445–463.
Describes canker of the bark, with methods of treatment. Reports finding the same fungus on blackened fruits. Summary in Trop. Agr., v. 24 (sup.), p. 52–53, 1905.

CARTON, L.
1924. Le caoutchouc en Indochine. *In* Bul. Écon. Indochine, ann. 27, p. 349–456.
General discussion of the diseases of Hevea in Indo China.

CAYLA, V.
1911. La lutte contre les maladies cryptogamiques dans les plantations d'Hévéa. D'après M. T. Petch. *In* Jour. Agr. Trop., ann. 11, p. 329–335.
Review of Petch, Physiology and diseases of Hevea brasiliensis. London, 1911.
1913. Maladies cryptogamiques des feuilles de l'Hévéa en Amerique. *In* Jour. Agr. Trop., ann. 13, p. 186–188.
Articles cited by various authors (Huber, Petch, Bancroft, Drost, etc.) on leaf diseases of Hevea.
1922. À propos de la maladie des feuilles de l'Hévéa en Amerique du Sud. *In* Agron. Colon., ann. 6, p. 17–19.

CEYLON. AGRICULTURAL EXPERIMENTS COMMITTEE.
1920. Prohibition of importation of Hevea seed from South America urged. *In* Trop. Agr., v. 54, p. 113–114. Also in Planters' Chron., v. 15, p. 277–278, 1920.
Attempt to prevent introduction of the South American leaf disease into the eastern Tropics.

CEYLON, DEPARTMENT OF AGRICULTURE, DIVISION OF BOTANY AND MYCOLOGY.
1922. A preliminary list of the diseases of cultivated plants in Ceylon. Bul. Dept. Agr. Ceylon 52, 24 p.
Arranged alphabetically by name of host.

CHANDLER, S. E.
1922. The brown bast disease of the Para rubber-tree. *In* Nature [London], v. 109, p. 357–360. Also in Trop. Agr., v. 59, p. 34–40, 1922.
Review of articles by Rands, Sanderson and Sutcliffe, Gandrup, Farmer, and Horne.

CHIPP, T. F.
1920. The fungus flora of Hevea brasiliensis. *In* Gard. Bul. Straits Settlements, v. 2, p. 186–192.
Lists fungous diseases of *Hevea brasiliensis* on Malay Peninsula grouped according to habitat.

1921. Another "wet rot" and Poria hypobrunnea. *In* Gard. Bul. Straits Settlements, v. 2, p. 429–432.
Root disease of *Hevea brasiliensis* on Malay Peninsula.

1921. A list of the fungi of the Malay Peninsula. *In* Gard. Bul. Straits Settlements, v. 2, p. 311–418. Bibliography, p. 401–403.
Reports 69 fungi found on rubber-producing plants.

COLENBRANDER, H.
1914. Behandeling van aan Fomes semitostis Lijdende 3-jarige Hevea brasiliensis. 9. p. Weltevreden. (Introd. Papers. Internat. Rubber Cong., Batavia, 1914.)
English translation, p. 5–9.

COLLET, O. J. A.
1904. L'Hévéa asiatique. Suite aux études pour une plantation d'arbres à Caoutchouc. Ed. 2, 84 p. Brussels.
Root disease is mentioned but no organism named.

CONDAMINE.
1751. Mémoire descriptive de l'arbe Seringue (ainsi nommé par les Portugais du Para; Heve par les habitans de la province d'Esmeraldas, au nord-ouest de Quito: Caoutchouc chez les Mainas). 330 p., illus. Paris.
Shows method and result of tapping at this early date.

COOK, M. T.
1913. The diseases of tropical plants. 317 p., illus. London. Bibliography: General, p. 289–290; Rubber, p. 303–304.
Chapter on rubber, p. 191–197, discusses cankers, Nectria, stem disease, die-back, fruit disease, seedling disease, and root diseases. Review by W. N. C. Belgrave in Agr. Bul. Fed. Malay States, v. 4, p. 21–22, 1915.

COSTER, J. C.
1920. Bestrijding van den bruinen binnenbast op de onderneming "Goenoeng Passang." *In* Arch. Rubbercult. Nederland.-Inide, jaarg. 4, Alg. Gedeelte, p. A338–A344, illus.
"In Voordrachten gehouden op de vergadering der Vereeniging tot bevordering van landbouw en nijverheid 'Djember' op 29 en 30 Juni 1920 te Banjoewangi."

CRAMER, P. J. S.
1910. De rubbercultuur op het Malcische Schiereiland. Bul. Dept. Landbouw Surinam 25, 138 p., illus.
Ziekten en plagen, p. 68–71. Mentions *Fomes semitostus* and white ants. Eng. translation in Proc. Agr. Soc. Trinidad and Tobago, v. 11, p. 3–130, 1911.

CROSS, R.
1898. Notes on American rubber-producing trees. *In* Fitzgerald, W. W. A., Travels in the coast lands of British East Africa, p. 678–706. London.
Reprint of two reports: 1. Report on the investigation and collecting of plants and seeds of the India-rubber trees of Para and Ceara to the undersecretary of state for India. 2. The American India-rubber trees in southern India. To the conservator of forests, Madras.

DASTUR, J. F.
1916. Black-thread disease of Hevea in Burma. Bul. Dept. Agr. Burma 14, 4 p., illus.
Caused by Phytophthora. For comments see Anstead, Bark-rot of Hevea, in Planters' Chron., v. 11, p. 382–383, 1916; also Bark-rot of Hevea in Burma, in India Rubber World, v. 55, p. 105, 1916, and in Trop. Agr., v. 48, p. 12–13. Abstract by J. Westerdijk in Indische Mercuur, jaarg. 39, p. 1119, 1916.

1916. Phytophthora sp. on Hevea brasiliensis. *In* Mem. Dept. Agr. India Bot. Ser., v. 8, p. 217–232, illus.

DETMANN, H.
1907. Krankheiten auf der Insel Ceylon. *In* Ztschr. Pflanzenkrank., Bd. 17, p. 343–345.
Hevea brasiliensis, p. 343–344. Abstract of articles by Petch in Circs. and Agr. Jour. Roy. Bot. Gard., Ceylon.

DILLEN, L. R. VAN, and GANDRUP, J.
1922. Een kleurmiddel voor desinfectântia bij de behandeling van streepjeskanker. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 220–225. (Meded. Besoekisch Proefstat. Rubberserie no. 26.)
English summary: A coloring matter for disinfectants in the treatment of the black-stripe disease, p. 225.

DROST, A. W.
1910. Verslag van den landbouwassistent. Verslag Dept. Landb. Surinam, 1910, p. 11–36.
Mentions leaf diseases of Hevea; no organism named.

EATON, B. J.
1915. The preparation of plantation Para rubber. *In* Trans. 3d Internat. Cong. Trop. Agr., London, 1914, v. 1, p. 652–678.
"Spot disease" of rubber, p. 671–674. Spot diseases have been proved by a number of investigators to be due to microorganisms, fungoid or bacterial in nature.

1917. Note on the development of chromogenic organisms in dry raw rubber allowed to become damp. *In* Agr. Bul. Fed. Malay States, v. 5, p. 177–179.
Experiments prove that rubber which leaves the estate clean and dry may develop spot disease if wet by rain or sea water during shipment.

1922. Chemical notes. *In* Malayan Agr. Jour., v. 10, p. 18–21.
Pink-spot on tree scrap and on blanket crêpe, caused by *Bacillus prodigiosus*.

——— GRANTHAM, J., and DAY, F. W. F.
1918. The preparation and vulcanisation of plantation Para rubber. Bul. Dept. Agr. Fed. Malay States 27, 13 p., illus.
"The development of spot disease in raw rubber and its influence on vulcanisation," p. 163–169.

EICHLER, A. G.
1866–68. Loranthaceae. *In* Martius, K. F. P. von, Flora brasiliensis, p. 102–104, Monachii and Lipsiae.
Systematic summary of genus Dendrophthora. No Brazilian species mentioned.

ELLIS, A. G. G.
1919. Notes on the work of the inspection staff during 1918. *In* Agr. Bul. Fed. Malay States, v. 7, p. 144–150.
Rubber diseases and pests, p. 146–148. No descriptions of fungi. See also reports for 1920 to date by F. W. South.

FARMER, J. B.
1918. Science and the rubber industry. *In* Jour. Roy. Soc. Arts, v. 66, p. 490–496. Discussion, p. 496–500. Also in Planters' Chron., v. 14, p. 145–146, 160–165, 182–183, 1919.

——— and HORNE, A. S.
1921. On brown bast and its immediate cause. *In* India-Rubber Jour., v. 61, p. 1225–1226, illus. Also in Planters' Chron., v. 16, p. 485–486, 1921. Rev. in Bul. Rubber Growers' Assoc., v. 3, p. 269–270, 1921.
Brown-bast is of physiological origin, but overtapping may not be the sole cause of the disease.

FIGART, D. M.
1925. The plantation rubber industry in the Middle East. U. S. Dept. Com., Trade Promotion Ser. No. 2, 317 p., illus.
Includes a short statement on diseases and pests.

FRANCIS, W.
1923. Report of the Department of Science and Agriculture for the year ended 31st December, 1921. *In* Brit. Guiana Rpt. Dept. Sci. and Agr., 1921, p. 1–21.
Data on the decrease of rubber yields due to the South American leaf disease.

GADD, C. H.
1924. Phytophthora faberi Maubl. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 9, p. 47–89, illus.
Comparative study of the strains of Phytophthora isolated from cacao, papaw, Hevea, Dendrobium, Odontadenia, and breadfruit in Ceylon. The strains used are regarded as biological varieties of *P. faberi*.

GALLAGHER, W. J.
1908. A root disease of Para (Hevea brasiliensis) rubber trees. *In* Agr. Bul. Straits and Fed. Malay States, v. 7, p. 515–522. Also in Trop. Agr. (Sup.), v. 31, p. 587–590, 1908.
"*Fomes semitostus* has been reported as a source of root disease here and in Ceylon. I have found it on only two occasions, and have not been able to connect it with the disease under discussion." In a further note, v. 8, p. 104, he refers to the disease as Fomes, or white fungus, root disease.

1908–09. Report of the government mycologist, Federated Malay States, for 1907–8. *In* Agr. Bul. Straits and Fed. Malay States, v. 7, p. 588–590; v. 8, p. 419–422.

1909. Field notes. *In* Agr. Bul. Straits and Fed. Malay States, v. 8, p. 104–107.
Root disease, catch crops, pruning, "warts," and "peas." Close planting.

1909. A preliminary note on a branch and stem disease of Hevea brasiliensis. Bul. Dept. Agr. Fed. Malay States 6, 6 p., illus.
Corticium zimmermani was found on some of the trees. A species of Sporocybe, probably saprophytic, and the perithecia and spores of one of the Hypocreaceæ are often found.

1909. Root diseases of Hevea brasiliensis, the Para rubber tree. Bul. Dept. Agr. Fed. Malay States 2, 13 p., illus.
Describes *Fomes semitostus* and a root disease caused by an unidentified fungus (later identified as *Hymenochaete noxia;* see preface to Bulletin no. 13, Dept. Agr. Fed. Malay States).

GALLAGHER, W. J.—Continued.
1910. Lecture on rubber sanitation. *In* Trop. Agr., v. 34, p. 267–268.
Report of a lecture given at Johore. Reprinted from Singapore Free Press, February 7, 1910. Discussion of Fomes, a branch and stem disease, and die-back.

GANDRUP, J.
1921. Over de kurklaag van heveaschors. *In* Arch. Rubbercult. Nederland.-Indie, jaarg., 5, p. 389–398. (Meded. Besoekisch Proefstat. Rubberserie no. 18). English summary: On the cork layer in the bark of Hevea, p. 397.
"This paper deals with the origin, growth, and throwing off of the cork in healthy untapped Hevea trees. It was intended to find out whether tissues injured by brown-bast disease are likely to be thrown off together with the external periderm layers." Conclusion reached is that they probably will not be cut off.

1921. Over den invloed van teer op Hevea-schors. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 549–562, illus. English summary, p. 561–562.
Meded. Besoek, Proefstat. Rubberserie no. 21. Inadvisable to make tar applications to black-thread canker.

1921. Over den steencellenring in de schors van Hevea. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 465–474. Literature cited, p. 474. (Meded. Besoekisch Proefstat., Rubberserie no. 19.) English summary: On the stone cell ring in the cortex of Hevea, p. 472.

1922. Over instervingsziekte bij Hevea. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 451–456. (Meded. Besoekisch Proefstat. Rubberserie no. 28). English summary: On the die-back disease of Hevea, p. 456.
Dying back of the young twigs may be caused by scarcity of light, heavy wind, lightning, bad soil, overtapping, and root disease. These show an appearance that is different from genuine die-back.

GARNIER, R.
1919. Ceylon rubber planters' manual. 206 p., illus.
Sanitation of rubber estates discussed.

GHESQUIÈRE, J.
1925. Travaux entomologiques au Kasai et au Sankuru. *In* Bul. Agr. Congo Belge, v. 16, p. 263–270.
"Liste des principaux parasites observés dans d'autres cultures que le coton" (p. 269) includes *Heterodera radicicola* and Ganoderma sp. on Hevea.

GRIFFON, E., and MAUBLANC, A.
1913. Sur quelques champignons parasites des plantes tropicales. *In* Bul. Soc. Mycol. France, tome 29, p. 244–250, illus.
Records *Dothidella ulei* on *Hevea brasiliensis* in Brazil.

GROENEWEGE, J.
1921. Over de oorzaak von rustiness op rubber van Hevea brasiliensis. Meded. Alg. Proefstat. Landb. 11, 19 p., illus.
Torula heveaensis the most important organism concerned.

GROVE, W. B.
1921. Mycological notes. VI. *In* Jour. Bot., v. 59, p. 311–315.
Description of *Placophomopsis heveae* n. g., n. sp., on *Hevea brasiliensis* from Uganda.

HALL, A. E. (DE JONGE) VAN.
1910. Bladziekte in de Hevea's. Bul. Dept. Landb. Surinam 24, 5 p. English summary, p. 5.
The disease is caused by a fungus living on the under side of the leaves, making spots which spread in concentric circles.

HALL, C. J. J. VAN.
1916–23. Ziekten en plagen der cultuurgewassen in Nederlandsch-Indie in 1915–1922. Meded. Inst. Plantenziekten Buitenzorg 20, 29, 33, 39, 46, 53, 58.
See also Rutgers, Ziekten en plagen der cultuur-gewassen in Nederlandsch-Indie in 1913–1914, Meded. Inst. Plantenziekten Buitenzorg 9 and 15, 1914–15.

1917. De bruine wortelschimmel (Hymenochaete noxia). *In* Teysmannia, jaarg. 28, p. 289–295.
Description of disease, recommendations for control, bibliography.

1919. [Brown bast.] *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 11, p. 388–389.

1919. De zuid-amerikaansche Hevea-bladziekte. *In* Teysmannia, jaarg. 30, p. 210–215.
Summary of bulletin by Stahel, Dept. Landb. Surinam Bul. 34, 1917.

——— and RUTGERS, A. A. L.
1914. Ziekten van Hevea. 5 p. Weltevreden. (Introd. Papers. Internat. Rubber Cong., Batavia, 1914). English translation, p. 3–5.
"Three diseases of the Hevea tree are more or less serious in Java, Sumatra, and the Malaya Peninsula: White-root fungus, canker, and pink disease."

HAMAKER, C. M.
1918. Bijhouden vragenlijst betreffende bruine binnenbast. *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 10, p. 886–892.
Discussion of brown-bast.

1918. De knobbelkanker in Hevea-plantsoenen. *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 10, p. 698–717.
Discussion of brown-bast and its control.

1920. 15 jaar rubbercultuur. *In* Publ. Nederland.-Indie Landb. Synd., jaarg. 12, p. 700–708.

——— and STOKHEKKER, H. C.
1919. [Brown bast.] *In* Publ. Nederland.-Indie Landb. Synd., jaarg. 11, p. 692.

HARMSEN, J. R.
1918. Eenige beschouwingen over bruine binnenbastziekte en uitkomsten van de gevolgde teermethode ter bestrijding van deze ziekte. *In* Nederland.-Ind. Rubbertijdschr., jaarg. 3 (2de halfjaar), p. 157–160, illus.
"Voordracht, gehouden in de Rubberplanters vergadering van den 29 en November, 1918." Reprinted in jaarg. 4, p. 69–74, 1919.

1919. Bruine binnenbast. Verdere belangrijke mededeelingen. *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 11, p. 366–385.

1920. Bruine-binnenbastziekte. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 4, Alg. Gedeelte, p. A214–A221.
Lecture delivered at the meeting of the Rubberplanters-vereeniging te Bandoeng, Feb. 25, 1920.

1921. The thinning out of rubber according to yield-records and the occurrence of brown bast. *In* Trop. Agr., v. 57, p. 75–81.
Lecture given at a meeting of the Rubber planters' association of Java, Bandoeng, Feb. 23, 1921. Tr. from the Dutch by A. C. Tutein-Nolthenius.

HARRISON, J. B.
1922. Report of the Department of Science and Agriculture for the year ended 31st of Dec., 1920. *In* Brit. Guiana Rpt. Dept. Sci. and Agr., 1920, p. 1–35.
Conditions affecting the development and spread of the South American leaf disease.

——— and STOCKDALE, F. A.
1911. Rubber and balata in British Guiana. 46 p., illus. Georgetown, Brit. Guiana.

HARTJENS, J. C.
1920. Vlekken op sheets in verband met het gebruik van sulfiet en bisulfiet. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 4, p. 137–161, illus. (Meded. Proefstat. Malang 31.) English summary: Spots on sheets in connection with the use of sulphite and bisulphite, p. 159–161. Abstract in Planters' Chron., v. 15, p. 369–370, 1920; and in Trop. Agr., v. 55, p. 6–7, 1920.

HELLENDOORN, H. J.
1919. Over het ontstaan van rustiness bij sheetrubber. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 3, p. 419–436. (Meded. Centraal Rubberstat.) English summary: On the cause of rustiness in sheet rubber, p. 431–436.
Experiments show that rustiness is caused by aërobic microorganisms. The microorganism has not been isolated.

HENNINGS, P.
1900. Fungi paraensis. I. *In* Hedwigia Beiblatt, Bd. 39, p. (78)–(80). Original description of Phyllachora huberi, p. (78).
Suggests that since no parasitic fungus had heretofore been found on Hevea, an important host, with greater distribution it should be considered serious.

1901. Fungi paraensis. (I). *In* Bol. Mus. Para, tome 3, p. 231–237.
Description of *Phyllachora huberi* on *Hevea brasiliensis*.

1904. Über die auf Hevea-arten bisher beobachteten parasitischen Pilze. *In* Notizbl. K. Bot. Gartens u. Mus. Berlin, Bd. 4, p. 133–138, illus.
New species: *Aposphaeria ulei, Dothidella ulei*, based on the collections of E. Ule in 1901/02 and on the work of Zimmerman published in 1901.

1904–05. Fungi amazonici a cl. Ernesto Ule collecti. I–IV. *In* Hedwigia, Bd. 43, p. 154–186, 242–273, 351–399; Bd. 44, p. 57–71, illus.
New species: *Aposphaeria ulei, Dothidella ulei, Ophiobolus heveae*.

HEURN, F. C. VAN, and HEUSSER, K.
1920. Vlekken op sheets. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 4, Alg. Gedeelte, p. A137–A139.

HOLLAND, T. H., and DEUTROM, H. A.
1924. [Report on diseases of rubber.] *In* Dept. Agr. Ceylon Bul. 70, p. 46.
Fomes lignosus gives most serious trouble; brown bast a negligible quantity, other diseases causing little trouble.

HOPE, R. J. H.
1919. Diseases of rubber plantations. *In* Trop. Agr., v. 52, p. 339–342.
Recommends Brunolinum Plantarium as a fungicide. Reprinted from Malayan Tin and Rubber Journal, v. 8, no. 7.

HORNE, A. S.
1921. Phloem necrosis (brown-bast disease) in Hevea brasiliensis. *In* Ann. Bot., v. 35, p. 457–459. Also in Bul. Rubber Growers' Assoc., v. 3, p. 271–272, 1921.
Material studied was from British North Borneo. Showed sieve-tube degeneration in the tissues affected.

1925. Further observations on phloem necrosis (brown-bast disease) in Hevea brasiliensis. *In* Rpt. Proc. Imp. Bot. Conf. London, 1924, p. 170–175.
"The discovery of sieve-tube necrosis in *Hevea brasiliensis* places the brown-bast disease in the category of obscure diseases in which the occurrence of phloem necrosis is a prominent feature, and the use of the expression does not necessarily imply the agency of a casual organism."
Reprinted in Trop. Agr., v. 64, p. 328–333. 1925.

HOUTE DE LANGE, W. G. TEN, JR.
1916. Bastvorming bij Hevea brasiliensis in verband met licht. Lumpvorming van latex in verband met licht. *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 8, p. 379–382.

HUBER, J.
1912. Relatorio sobre o estado actual da cultura da Hevea brasiliensis nos principaes paizes de produccao do Oriente . . . 116 p., illus. Belem. Molestias e inimigos da seringueira cultivada: p. 100–105.

JARDINE, N. K.
1923. Report of division of plant pests and diseases inspection (Central). *In* Ceylon Dept. Agr. Rpt. 1922, p. 20–21.
Several fungi reported on rubber.

JAVA (MIDDLE). PROEFSTATION MALANG.
1917. Werkzaamheden, in het belang van de rubbercultuur, verricht aan het proefstation Malang. (1916.) *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 1, p. 188–196. (Meded. Proefstat. Malang.) "Ziekten en plagen," p. 188–190. Extract from the Jaarverslag, 1916.

JOHNSON, W. H.
1909. The cultivation and preparation of Para rubber. Ed. 2, 178 p., illus. London.
Fungus diseases, p. 52–59. Numerous species mentioned.

JONES, J.
1916. Items of local interest. *In* Agr. News [Barbados], v. 15, p. 347.
Reports Rosellinia on Para rubber in Dominica.

JUMELLE, H.
1915. Les cultures coloniales. v. 7. Plantes à latex et à résines. Ed. 2, 119 p. Paris. Hévéa-Ennemis et maladies, p. 63–65. Common fungus parasites listed.

KEUCHENIUS, P. E.
1914. Het prikken van Hevea en zijn pathologische consequenties. *In* Meded. Besoekisch Proefstat. 10, p. 1–3, illus.

1917. Phytopathologische aantoekeningen over Hevea. *In* Meded. Besoekisch Proefstat. 24, p. 49–54.

1917. Verslag van een bezoek aan eenige rubberlanden in West-Java. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 1, p. 73–88. Ziekten en plagen, p. 81–82.

1918. Korte mededeelingen over Hevea. *In* Arch. Rubbercult. Nederland.–Indie, jaarg. 2, p. 433–436. (Meded. Besoekisch Proefstat., Rubberserie 6.)
Canker may arise from superficial bark wounds.

1920. Ondérzoekingen over bruine bastziekte. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 4, p. 495–497, illus. (Meded. Plantation Research Dept. H. A. P. M.) English summary: Ring-rot, a new disease of Hevea, p. 497.
A bark disease common in Sumatra and also observed in the Straits Settlements and in the Federated Malay States. Cause is not yet known with certainty, but it seems to be due to a fungus.

1920. Ondérzoekingen over bruine bastziekte. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 4, p. 1–4. (Meded. Plantation Research Dept. H. A. P. M.) English summary: Investigations on brown bast, p. 4.
"Up till now sufficient evidence has not been given to show that brown bast has a physiological cause * * * It seems necessary to give attention to the infection theory and to do more experimental bacteriological work on brown bast."

1921. Die Rindenbräune der Hevea brasiliensis; eine kritische Untersuchung. *In* Centbl. Bakt., Abt. 2, Bd. 55, p. 14–74, illus. Bibliography, p. 73–74. Abstract in Rev. Appl. Mycol., v. 1, p. 263–267, 1922.
The disease is infectious and is caused by parasitic bacteria found in the latex vessels.

1922. Eenige onderzoekingen in verband met de bestrijding van zwarte draadziekte. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 403–408. (Meded. Plantation Research Dept. H. A. P. M.)
A comparative study of various fungicides. English summary, p. 408.

1923. Ervaringen uit de praktijl der bruine bast bestrijding. *In* Arch. Rubbercult. Nederland.–Indie, jaarg. 7, p. 382–385. (Meded. Plantation Research Dept. U. S. R. P. inc.)

1924. Beschouwingen over bruine bastziekte. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 8, p. 803–816, illus.

KEW, ROYAL BOTANICAL GARDENS.
1898–1920. Fungi exotici, I. XIII, XVI, XVIII, XXIV, XXV. *In* Kew, Roy. Bot. Gard. Bul. 1898, p. 113–136; 1912, p. 189–191; 1913, p. 104–105; 1914, p. 156–159; 1918, p. 207–210; 1920, p. 289–300.
Other installments contain nothing on rubber; I, XIII, XVI by G. E. Massee; XVIII, XXIV, XXV by E. M. Wakefield(?).

KNISCHEWSKY, O.
1908–11. Krankheiten tropischer Nutzpflanzen. *In* Ztschr. Pflanzenkrank., Bd. 18, p. 276–285; 20, p. 265–268; 21, p. 216–225, 454–467.
Abstracted from articles in various periodicals.

1913–15. Mitteilungen aus Holländisch-Indien (Beiträge zur Statistik). *In* Ztschr. Pflanzenkrank., Bd. 23, p. 145–151; 25, p. 461–463.
Fomes sp. and *Pestalozzia palmarum* reported on Hevea (1913); leaf disease and *Bacterium prodigiosum* (1915).

KNOWLES, C. H.
1916–20. Division of Plant Pathology. 1915–1919. *In* Ann. Rpt. Dept. Agr. Fiji Isl., 1915, p. 26–31; 1916, p. 29–31; 1917, p. 15–17; 1918, p. 19–21; 1919, p. 15–16.

KOK, G. L. J. D.
1915. Groene wortelschimmel. *In* Alg. Ver. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915/16, p. 16–17.
Describes a blue-green fungus found on the roots of Hevea.

KOORDERS, S. H.
1906. Notiz über Gloeosporium elasticae Cooke et Massee. *In* Notizbl. K. Bot. Gartens u. Mus. Berlin, Bd. 4, p. 251–252.
Establishes the identity of *Gloeosporium elasticae* and *Colletotrichum ficus*.

1907. Botanische Untersuchungen über einige in Java verkommende Pilze, besonders über Blätter bewohnende parasitisch auftretende Arten. Verhandl. K. Akad. Wetensch. Amsterdam 4 (Sect. 2, Deel 13), 264 p., illus.

KUYPER, J.
1911. Eine Heveablattkrankheit in Surinam. *In* Rec. Trav. Bot. Néerland., v. 8, p. 371–379, illus.
Same article without Latin diagnosis (Een Fusicladium-ziekte op Hevea) in Bul. Dept. Landb. Surinam 28, p. 3–10. 1912. Disease is caused by *Fusicladium macrosporum*, which attacks *Hevea brasiliensis* and *H. guyanensis*. Summary in Jour. Bd. Agr. Brit Guiana, v. 6, p. 103–104, 1913.

1913. Een paar eigenaardige verschijnselen bij Hevea brasiliensis. *In* Bul. Dept. Landb. Surinam 30, p. 48–55, illus.

1913. Maserbildung bei Hevea brasiliensis. *In* Rec. Trav. Bot. Néerland., v. 10, p. 137–146, illus.

1914. Die erneuerung von Hevea-bast nach dem anzapfen. *In* Internat. Rubber Cong. and Exhib. Batavia, 1914, Rubber Rec., p. 93–99.
Based on observations made in Paramaribo, Dutch Guiana.

LAMONT, N., and OTHERS.
1917. Rubber cultivation in Trinidad and Tobago. Report of the special committee of the Board of Agriculture. *In* Bul. Dept. Agr. Trinidad and Tobago, v. 16, p. 95–127.
Only disease affecting Hevea in the region appears to be the South American leaf disease.

LA RUE, C. D.
1921. Lightning injury in Hevea brasiliensis. (Abstract.) *In* Phytopathology, v. 11, p. 46. Also in Mycologia, v. 13, p. 125, 1921.
Progressive death of tissues is suggestive of invasion by some destruction organism. Cultures show the presence of *Diplodia rapax*, but this is now known to be secondary and not the cause of the death of the tree.

1922. Helminthosporium heveae Petch in Sumatra. (Abstract.) *In* Phytopathology, v. 12, p. 60.
Usually attacks young trees, but occasionally found on old ones; in some cases the leaves were riddled with spots, but the disease does not cause defoliation.

1922. Lightning injury to Hevea brasiliensis. *In* Phytopathology, v. 12, p. 386–389.
Trees of *Hevea brasiliensis* are frequently injured or killed by lightning. Such cases of injury are usually wrongly diagnosed as Diplodia die-back.

1923. Helminthosporium heveae in Sumatra. *In* Phytopathology, v. 13, p. 483–487.
Usually infests nurseries, but sometimes attacks mature trees. The spores of the fungus in Sumatra appear to be smaller than those measured by Petch in Ceylon.

1923. Two unreported parasites of Hevea brasiliensis. *In* Papers Mich. Acad. Sci. Arts and Letters, v. 2, p. 69-71.
Sclerotium sp. and *Cephaleuros virescens* Kunze.

1924. Notes on the failure of the seed crop of Hevea brasiliensis on the east coast of Sumatra. *In* Papers Mich. Acad. Sci., v. 3, p. 193–201.
Gloeosporium alborubrum Petch constantly associated with phenomena of fruit and flower fall.

——— and BARTLETT, H. H.
1923. Diplodia disease of Hevea brasiliensis. *In* Papers Mich. Acad. Sci. Arts and Letters, v. 2, p. 91–107.
Diplodia is believed to be cause of seed deterioration, moldy rot, and black-thread.

1923. A leaf-fall disease of Hevea brasiliensis Muell.-Arg. due to Gloeosporium alborubrum Petch. *In* Papers Mich. Acad. Sci. Arts and Letters, v. 2, p. 73–90.
The disease appears to be physiological in the sense that the infection to which the disease is attributed produces its characteristic symptoms only when the meteorological conditions are favorable.

LEE, H. A., and YATES, H. S.
1919. Pink disease in citrus. *In* Philippine Jour. Sci., v. 14, p. 657–671. Also in Trop. Agr., v. 54, p. 103–107, 1920.
Not yet reported on *Hevea brasiliensis* in the Philippine Islands.

1920. The distribution of pink disease. *In* Philippine Agr. Rev., v. 13, p. 115–116.

[LEECHMAN, A.]
1913. Rubber disease—a warning. *In* Jour. Bd. Agr. Brit. Guiana, v. 6, p. 103–104.
Calls attention to Kuyper's Bul. 28, Surinam Dept. Landb., on *Fusicladium macrosporum*.

[LEECHMAN, A.]—Continued.
1916. Fighting the South American leaf disease of Hevea. *In* Jour. Bd. Agr. Brit. Guiana, v. 10, p. 1–4.
Abstract of article by Stahel, in Meded. Dept. Landb. Surinam, no. 6, 1916, with comments.
1917. Diseases of Hevea. *In* Jour. Bd. Agr. Brit. Guiana, v. 10, p. 115–116.
Summary of Petch, Diseases of Hevea, in Trop. Agr., v. 47, p. 275–281, 1916; with remarks on conditions in British Guiana.

LENNEP, H. H. T. VAN.
1919. Mededeelingen over bruine-binnenbast. *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 11, p. 83–98.
Cause and control of brown-bast. Discussion, p. 68–69.

LEWTON-BRAIN, L.
1913–14. Agriculture in Malaya in 1912, 1913. Dept. Agr. Fed. Malay States Bul. 18 and 20. Fungus diseases of rubber, Bul. 18, p. 17–18; 20, p. 14.

LOCK, R. H.
1910–11. Report of the assistant director (including mycology). 1910–11. *In* Rpt. Dir. Roy. Bot. Gard. Ceylon 1910–11, p. 4–5.
See also earlier reports by Carruthers or Petch. Beginning with 1911–12, reports (by Petch) are published by the Ceylon Department of Agriculture.
1913. Rubber and rubber planting. 245 p., illus. Cambridge. "The pests and diseases of Hevea," p. 176–196.

MAAS, J. G. J. A.
1919. Phytophthora meadii McRae op Hevea brasiliensis. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 3, Alg. Gedeelte, p. A115–A118.
Summarizes McRae's work on *Phytophthora meadii*.
1921. Herkenning en bestrijding van de voornaamste ziekten en beschadigingen van Hevea brasiliensis. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 55–65. (Meded. Alg. Proefstat. A. V. R. O. S. Rubberserie no. 28.)
In two parts: (1) Descriptions of diseases; (2) treatment.
1922. Bestrijding van streepkanker. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 513–515.
Comment on Keuchenius, Eenige onderzoekingen in verband met de bestrijding van zwarte draadziekte, in Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 403–408, 1922.
1923. Bruine binnenbast bestrijding. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 7, p. 253–257.
Methods of treating brown-bast.
1923. Eenige gevallen van bliksemschade bij Hevea. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 7, p. 124–129, illus.
Effects of lightning injury on Hevea.
1925. Het tapsysteem van Hevea brasiliensis op proefondervindelijken grondslag. Hoofdstuk II. De geschiedenis van het tapsysteem. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 9, p. 18–41.
Describes various methods of tapping and effects therefrom.

MCRAE, W.
1916. Abnormal leaf-fall of Hevea rubber. *In* Planters' Chron., v. 11, p. 459–465. (Lecture delivered at annual meeting of U. P. A. S. I.)
Summary of leaf-fall and other diseases caused by Phytophthora in southern India.
1917. Abnormal leaf-fall of Hevea. *In* Planters' Chron., v. 12, p. 487–489. (Paper read at annual meeting of U. P. A. S. I.)
1917. Second leaf-fall in Hevea. *In* Trop. Agr., v. 48, p. 169.
Quoted from Report of the Govt. Mycologist, Madras, 1915–16.
1918. Fungoid diseases of rubber in southern India. *In* Planters' Chron., v. 13, p. 395–401.
Address before rubber-planters' conference at Cochin. *Phytophthora faberi, P. meadii*. Control experiments.
1918. A new species of Phytophthora parasitic on the Para rubber tree. *In* Jour. Bombay Nat. Hist. Soc., v. 25, p. 760.
Description of this fungus, which causes leaf-fall, fruit-rot, die-back, and rot of tapped surface.
1918. Phytophthora meadii n. sp. on Hevea brasiliensis. *In* Mem. Dept. Agr. India Bot. Ser., v. 9, p. 219–273, illus.
Deals with inoculation experiments, characteristics, effect on plant tissues, preventive measures, etc.
1919. A disease of the Para rubber tree caused by Phytophthora meadii McR. *In* Agr. Jour. India, v. 14, p. 566–577, illus.
Effects of *Phytophthora meadii* are leaf-fall, fruit-rot, die-back, and bark rot.
1920. The Surinam or South American leaf disease. *In* Planters' Chron., v. 15, p. 303–305.
This disease has put an end to rubber cultivation in Surinam, but is not yet found in the eastern Tropics. Caused by *Fusicladium macrosporum*.

——— and ANSTEAD, R. D.
1918. Abnormal leaf fall of Hevea rubber. Programme of experimental work for 1918. *In* Planters' Chron., v. 13, p. 38–40.

——— and SUNDARARAMAN, S.
1915. Leaf fall of Hevea. *In* Planters' Chron., v. 10, p. 452–454.
Fungus found to agree with *Phytophthora faberi* (*P. theobromae*).

MARKHAM, C. R.
1880. Peruvian bark. 550 p., illus. London.
Caoutchouc cultivation in British India, p. 441–466. Contains an account of the expedition of Robert Cross to South America to obtain rubber trees.

MASSEE, G. E.
1901. Diseased roots of Para rubber trees from Singapore. *In* Agr. Bul. Straits and Fed. Malay States, v. 1, p. 81–82.
Roots are attacked by a fungus belonging to the genus Helicobasidium, which appears to be very closely allied to, if not identical with *H. mompa.*

1910. Diseases of cultivated plants and trees. 602 p., illus. London.
Describes *Fomes semitostus* and *Corticium javanicum,* found on *Hevea brasiliensis.*

1910. Fungus on Para rubber from Singapore. *In* Planters' Chron., v. 4, p. 368.
Diplodia rapax, also found on Hevea from West Africa.

1911. "Die-back" of cacao and of Para rubber. *In* Kew, Roy. Bot. Gard. Bul. 1911, p. 120–121.
Diplodia cacaoicola is followed by an ascigerous stage which has been identified as *Thyridaria tarda.*

1913. Diseases caused by fungi. *In* Brown, E., and Hunter, H. H. Planting in Uganda, p. 151–167, illus. London.
Describes *Fomes lignosus,* black-blight, brown-root disease, canker, and pink-fungus disease of Hevea.

MITCHELL, J.
1911. Some diseases of Hevea brasiliensis. *In* Internat. Rubber Conf., 2d, London, 1911, The rubber industry, p. 180–189.
Discusses four fungi: *Fomes semitostus, Hymenochaete noxia, Corticium javanicum,* and "die-back."

1916. Diseases and pests. *In* Times (London), Imp. and Foreign Trade Sup., Dec. 1916, Plantation Rubber Sect., p. 16.
Hevea brasiliensis is the only host species to which reference is made. Discusses die-back, pink disease, canker, nodules, *Fomes lignosus,* brown-thread root disease. *Sphaerostilbe repens, Ustulina zonata.*

1923–24. Work of Ceylon rubber research scheme, 1921/22–1923. *In* Trop. Agr., v. 60, p. 325–327; 62, p. 323–335.

MORANGE, A.
1910. Note sommaire au suject des maladies cryptogamiques de l'Hévéa brasiliensis. *In* Bul. Écon. Indo-chine, v. 13, p. 150–153.

MORGAN, S., and STEVENS, H. P.
1922. The preparation of plantation rubber. 331 p., illus. London.
Chapters 17 and 18 discuss molds, spotting, and various discolorations of prepared rubber.

NORRIS, F. DE LA M.
1920. Notes on the field treatment of mouldy rot. *In* Agr. Bul. Fed. Malay States, v. 8, p. 113–116.
Extracts from notes on the field control of moldy rot, supplied by managers of various estates in the infected regions.

NOWELL, W.
1914. Report on the prevalence of some pests and diseases in the West Indies. Pt. II. Fungoid and bacterial diseases. 1913. *In* West Indian Bul., v. 14, p. 209–214.
See also reports for 1909/10–1910/11, by F. W. South; 1912, by H. A. Ballou.

1915. Root diseases in Malaya. *In* Agr. News [Barbados], v. 14, p. 174–175.
Summary of two papers by Brooks in Agr. Bul. Fed. Malay States, v. 3, p. 40–43, 105–107, 1914. The diseases considered are *Sphaerostilbe repens* and *Ustulina zonata.*

1916. Pink disease in the West Indies. *In* Agr. News [Barbados], v. 15, p. 238–239.
The same disease which attacks Hevea in the East is reported on cacao, limes, etc., in the West Indies. At first wrongly determined as *Corticium lilacino-fuscum,* it was later referred to *Corticium salmonicolor.*

1923. Diseases of crop-plants in the Lesser Antilles. 383 p., illus. London. Diseases of Hevea, p. 232–234.

OLSSON-SEFFER, P.
1910. Bibliography of rubber. *In* Amer. Rev. Trop. Agr., v. 1, p. 173–177, 214–216, 257–260.
Through Faivre. No more published. Includes various citations to pathology of Hevea.

OLT, J. H. C.
1919. Basiziekten bij Hevea. *In* Publ. Nederland.-Indie, Landb. Synd., jaarg. 11, p. 224–225.

OVEREEM, C. VAN.

1924. Over het optreden van zwarte wortelschimmel (Rosellinia) bij rubber en koffie. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 8, p. 135–137. English summary, p. 142. Bibliography, p. 137.

Black-root disease has been known on coffee for some time, but has only recently been found on rubber. The specific name of the fungus is probably *Rosellinia bunodes* (Berk. and Broome) Sacc., but absolute certainty on this point could not be attained, organs of fructification being wanting.

1924. Über Ustulina vulgaris Tul. und Ustulina zonata (Lev.) Sacc. *In* Bul. Jard. Bot. Buitenzorg, ser. 3, v. 6, p. 256–263.

1925. Over het voorkomen van Ganoderma lucidum (Leysser) Karsten in Rubbertuinen. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 9, p. 518–521, illus. English: On the occurrence of Ganoderma lucidum (Leysser) Karsten in rubber fields, p. 526. Meded. Rubberproefstat. "West Java." Phytoph. Ser. III.

——— and STEINMANN, A.

1923. Over de roode wortelschimmel van Hevea brasiliensis. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 7, p. 453–460, illus. (Meded. Rubberproefstat. "West-Java." Phytopathologische serie no. 1, pt. 4.)

English summary: The red-root disease of rubber trees in Java caused by *Ganoderma ferreum*, p. 466. The disease was originally attributed to *Poria hypolateritia;* later described from Straits as *Fomes pseudoferreus;* now identified in Java as *Fomes ferreus*, which should be called *Ganoderma ferreum.* Summary in English in Trop. Agr., v. 61, p. 370, 1923.

——— and WEESE, J.

1924. Icones fungorum Malayensium, Heft V, Polyporaceæ. 5 p., illus. Wien.

Pathological significance of *Polyporus lignosus* mentioned, and attempt to prove that this species and *Polyporus zonalis* are identical.

PARNELL, F. R.

1921. Rubber trees resistant to leaf-fall. *In* Planters' Chron., v. 16, p. 77–79.

Methods for control of leaf-fall (*Phytophthora meadii*).

PATOUILLARD, N.

1910. Les maladies de l'Hévéa brasiliensis. *In* Jour. Agr. Trop., v. 10, p. 170–171.

Enumeration of fungi reported on Hevea.

PETCH, T.

1905–06. Mycological notes. *In* Trop. Agr., v. 24 (sup.), p. 137–138; 25, p. 298–299, 411–413, 523–524, 630–631, 777; 27, p. 86–87.

Other installments contain nothing on rubber. Sept., 1905, installment reprinted in Agr. Bul. Straits and Fed. Malay States, Oct., 1905.

1905–09. Report of the Government Mycologist, 1905–1909. *In* Rpt. Dir. Roy. Bot. Gard. Ceylon, 1905, p. 3–7; 1906, p. 4–9; 1907, p. 5–8; 1908, p. 3–4; 1909, p. 6–8.

See also reports for 1900–1904 by J. B. Carruthers; 1910/11, by R. H. Lock. Beginning with 1911/12, reports (by Petch) are published by the Ceylon Department of Agriculture. Report for 1905 is reprinted in Circ. and Agr. Jour., v. 3, p. 280–282; and the section on diseases of *Hevea brasiliensis*, 1905, is reprinted in Agr. Bul. Straits and Fed. Malay States, v. 5, p. 396–398, 1906. 1907 Report in Planters' Chron., v. 3, p. 145–146, 1908.

1906. Descriptions of new Ceylon fungi. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 3, p. 1–10.

Fifteen of the fungi described are found on rubber-producing plants, most of them on *Hevea brasiliensis.*

1906. Precautions against fungus diseases. *In* Willis, J. C., and others. Rubber in the east. p. 36–41. Colombo.

Discusses danger of disease in nurseries, canker, and *Fomes semitostus.*

1906. Root disease of Hevea brasiliensis, Fomes semitostus Berk. *In* Circs. and Agr. Jour. Roy. Bot. Gard. Ceylon, v. 3, p. 237–242, illus.

Description of the fungus, with suggestions for treatment. Ceylon.

1907. Canker in Para rubber trees. *In* Indian Agr., v. 32, p. 190. Also in Planters' Chron., v. 2, p. 132–133, 1907.

A reply to Cameron, Canker in Para rubber trees, in Trop. Agr., v. 28, p. 412–413, 1907. Natural scaling off of bark may be mistaken for canker.

1907. Moulds and rubber. *In* Trop. Agr., v. 28, p. 9–12.

The commonest mold on rubber in Ceylon is *Eurotium candidum.*

1907–19. Revisions of Ceylon fungi. Pt. I–VI. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 4, p. 21–68, 373–444; 5, p. 265–301; 6, p. 153–183, 307–355; 7, p. 1–44.

Names of hosts are included in only a few descriptions.

1908. Die Pilze von Hevea brasiliensis (Para kautschuk). *In* Ztschr. Pflanzenkrank., Bd. 18, p. 81–92. Literatur, p. 91–92.

Contents: Blattkrankheiten; Worzel-krankheiten; Stamm und Zweigkrankheiten; Krankheiten der Früchte; Präparierte kautschuk.

1908. Root disease of Para rubber. *In* Trop. Agr., v. 31, p. 590.

Fomes semitostus still confined to areas (in Ceylon) in which it first appeared.

1909. Abnormalities in Hevea brasiliensis. I. Twisted seedings. *In* Circs. and Agr. Jour. Roy. Bot. Gard.-Peradeniya, v. 4, p. 147–154, illus.

PETCH, T.—Continued.

1909. Abnormalities in Hevea brasiliensis. II. Burrs and nodules. *In* Circs. and Agr. Jour. Roy. Bot. Gard., Ceylon, v. 4, p. 155–164, illus.
Two types of burs are considered, one caused by wounds and the other to some extent a natural habit of *Hevea brasiliensis*.

1909. A bark disease of Hevea, tea, etc. (Corticium javanicum Zimm.) *In* Circs. and Agr. Jour. Roy. Bot. Gard., Ceylon, v. 4, p. 189–196.
Pink disease attacks many different kinds of trees and probably spreads from jungle plants. Has been reported from Java, southern India, and Ceylon. Disease attributed to *Corticium calceum* in the Federated Malay States is probably the same.

1909. New diseases of rubber. *In* Trop. Agr., v. 33, p. 377–381.
Address before Kelani Valley Planters' Association. Mentions pink disease, die-back, and claret-colored canker. Review in Agr. Bul. Straits and Fed. Malay States. v. 8, p. 535–536, 1909.

1909. Thumb-nail pruning and disease. *In* Trop. Agr., v. 33, p. 98–100.
Review of article by Ryckman, in Jour. Agr. Trop., ann. 9, p. 5–7, 1909.

1909–10. Miscellanea: chiefly pathological. *In* Trop. Agr., v. 32, p. 445–446; 33, p. 239–241, 429–431, 521–522; 34, p. 40–42, 123–125, 225–227; 35, p. 223–225, 418–419.
Other installments contain nothing on rubber diseases.

1910. Brown root disease (Hymenochaete noxia, Berk.). *In* Circs. and Agr. Jour. Roy. Bot. Gard., Ceylon, v. 5, p. 47–54, illus.
It is the commonest root disease of Hevea in Ceylon, and also attacks many other plants. Found in southern India, Java, and throughout the eastern Tropics and causes some loss in plantations of all descriptions. Summary in Trop. Agr., v. 35, p. 180–181, 1910.

1910. Cacao and Hevea canker. *In* Circs. and Agr. Jour. Roy Bot. Gard., Ceylon, v. 5, p. 143–180.
Gives results of inoculation experiments which prove that cacao and Hevea cankers and pod disease are caused by the same fungus, *Phytophthora faberi*. Description of the fungus and treatment.

1910. Die-back of Hevea brasiliensis. *In* Circs. and Agr. Jour. Roy. Bot. Gard., Ceylon, v. 4, p. 307–321.
Green branches are killed by *Gloeosporium alborubrum*. This is followed by *Botryodiplodia elasticae*, which may kill the entire tree. Discusses the identity of *B. elastica* with other Diplodia species which attack plants in other parts of the world. Reports a climatic leaf fall. Review in Trop. Agr., v. 34, p. 286–287, 1910.

1910. On Lasiodiplodia. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 4, p. 445–465.
Establishes the synonymy: *Botryodiplodia theobromae* Pat. (1892); *Macrophoma vestita* Prill. and Del. (1894); *Diplodia cacaoicola* Henn. (1895); *Lasiodiplodia nigra* Appel and Laub. (1906); *Botryodiplodia elasticae* Petch (1906); *Chaetodiplodia grisea* Petch (1906); *Lasiodiplodia* sp. Charles (1906); *Chaetodiplodia* sp. Van Hall and Drost (1908). Review in Ztschr. Pflanzenkrank., Bd. 23, p. 242, 1912; Agr. Bul. Straits and Fed. Malay States, v. 10, p. 76, 1911.

1910. A root disease of Hevea (Sphaerostilbe repens, B. and Br.). *In* Circs, and Agr. Jour. Roy. Bot. Gard., Ceylon, v. 5, p. 65–71, illus.
Gives characteristics of the disease, description of the fungus, sources of infection, and treatment. Not a widespread disease in Ceylon.

1911. The physiology and diseases of Hevea brasiliensis, the premier plantation rubber tree. 268 p., illus. London.
Chapter 8 discusses general sanitation; chapters 9 to 14 diseases and abnormalities.

1912–22. Report on the work of the botanical and mycological division, 1911/12–1914, 1916–1919, 1922. *In* Rpt. Dept. Agr. Ceylon, 1911/12, p. 5–6; 1912/13, p. 7–9; 1914, p. 8–11; 1916, p. 6–7; 1917, p. 9–10; 1918, p. 10–11; 1919, p. 5–8; 1922, p. 17–18. Title varies slightly.
See also reports for 1915, 1920, by Bryce. Before 1911/12, reports (by Carruthers, Petch, or Lock) are published by Peradeniya Royal botanic gardens. 1921 printed in Trop. Agr., v. 58, p. 214–216; 1912/1913 report reviewed in Trop. Agr., v. 45, p. 230. 1915.

1912. Root disease of Hevea. *In* Trop. Agr., v. 39, p. 153–156.
Largely a review of Bancroft, Root disease of the Para rubber tree, Dept. Agr. Fed. Malay States Bul. 13, 1912. Bancroft identifies the fungus as *Fomes semitostus*, but according to Lloyd it should be known as *Polyporus lignosus*.

1912. Rubber-tree diseases. *In* Trop. Agr., v. 39, p. 321–325. Also in Planters' Chron., v. 7, p. 601–604. 617–618, 1912.
Lecture to Kalutara Planters' Association, on Hevea canker.

1913. Papers and records relating to Ceylon mycology and plant pathology, 1783–1910. A bibliography. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 5, p. 343–386.
Includes references to literature on a pathology of Hevea.

1914. The fungus diseases of Hevea brasiliensis. *In* Internat. Rubber Cong. and Exhib., Batavia, 1914, Rubber Rec., p. 116–129.
"No new diseases of any importance have been recorded during the last seven years." Describes the important diseases of roots, stem, and leaves.

PETCH, T.—Continued.

1914. Leaf diseases of Hevea. *In* Trop. Agr., v. 42, p. 268–269.
Short summary of literature on various leaf diseases with conclusion that they are probably identical, namely, South American leaf disease.

1915. Diseases of Hevea in Ceylon. *In* Trans. 3d Internat. Cong. Trop. Agr., London, 1914, v. 1, p. 596–607. Abstract in its Proc., 1914, p. 172.
Confined to diseases which are of practical importance in Ceylon; brown-root disease, pink disease, die-back, canker, burs, decay of tapped cortex. Canker is the most serious disease in Ceylon.

1915. Horse hair blights. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 6, p. 43–68, illus.
Marasmius equicrinis has been observed at the base of Hevea trees, where it grows on the outer dead bark. The mycelium does not appear to be parasitic. Ceylon.

1915. The pseudo-sclerotia of Lentinus similis and Lentinus infundibuliformis. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 6, p. 1–18, illus.
Lentinus similis was found on a decaying stump of *Hevea brasiliensis* in Ceylon.

1916. Diseases of Hevea. *In* Trop. Agr., v. 47, p. 275–281.
Full text of the lecture delivered at Taldua on Sept. 23 and at Tebuwana on Sept. 25, 1916. Discusses *Fomes semitostus, Ustulina zonata, Poria hypobrunnea,* Diplodia sp., fruit diseases, and canker.

1916. A preliminary list of Ceylon Polypori. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 6, p. 87–144.
Name of host included in very few instances; *Fomes lignosus* the only one reported growing on rubber-producing plants.

1917–21. Quarterly progress report of the botanist and mycologist. Apr./Je. 1917, Jl./Sept. 1917, Apr./Je. 1918, Apr./Je. 1921, Jl./Sept. 1921. *In* Trop. Agr., v. 49, p. 175, 357–358; 51, p. 100; 57, p. 192–194, 318–319. Title varies.

1917–22. Additions to Ceylon fungi. I–II. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 6, p. 195–256; 7, p. 279–322.

1918. The application of preservatives to renewing bark of rubber. *In* Trop. Agr., v. 51, p. 40–45. (Leaflet no. 9, Dept. Agr. Ceylon.)
Various solutions recommended for prevention of bark rot (black-stripe).

1918. Hevea bark disease. *In* Trop. Agr., v. 50, p. 14–17.
Address given by the Government botanist and mycologist to the Haputale Planters' Association. May be same as brown canker found on the Malay Peninsula.

1919. Brown bast. *In* Trop. Agr., v. 52, p. 333–335; 53, p. 133–138. Revised in v. 57, p. 371–373, 1921.
Not caused by any fungus or bacterium, but is due to some interference with the normal physiological functions of the tree.

1919. Rubber diseases. *In* Trop. Agr., v. 52, p. 27–34.
Address at a meeting of the Kelani Valley Planters' Association at Taldua, Nov. 23, 1918. Discusses *Poria hypobrunnea,* root diseases in general, tree surgery, white stem blight, and top canker.

1919. Rustiness in smoked sheet. *In* Trop. Agr., v. 53, p. 361–363. Abstract and review of article by Hellendorn in Arch. Rubbercult. Nederland.-Indie, jaarg. 3, p. 419–436, 1919.
Hellendorn concludes that rustiness is not caused by a film of serum constituents, notably proteins, merely dried on the surface of the sheet, but by the decomposition of the serum constituents by a micro-organism. The organism has not been isolated.

1920. Hypocreaceae zeylanicae. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 7, p. 85–138.
A few species found growing on rubber plants. Host is not mentioned in most instances.

1921. Brown bast. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 446–447.
Refutes the statement by Rands (Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 227, 1921) that the confusion between brown-bast and claret-colored canker arose in Ceylon.

1921. The diseases and pests of the rubber tree. 278 p., illus. London. Bibliography, p. 268–274.
Chapters on root diseases, leaf diseases, Phytophthora diseases, stem diseases, nonparasitic diseases, abnormalities, etc., with summary at end of each chapter. A revision of part of his The physiology and diseases of Hevea brasiliensis. 1911. Abstract in Rev. Appl. Mycol., v. 1, p. 134–136, 1922.

1921. Studies in entomogenous fungi: II. The genera Hypocrella and Aschersonia. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 7, p. 167–278, illus.
Fungi parasitic on scale insects, some of which are found on rubber-producing plants.

1922. Report of the mycological division, 1921. *In* Trop. Agr., v. 58, p. 214–216. (From 68th Ann. Rpt. Planters' Assoc. Ceylon.)
Probably only extracts, original report not seen.

1923. New diseases of Ceylon plants. *In* Trop. Agr., v. 60, p. 129–130.
Xylaria thwaitesii on roots and *Daldinia concentrica* on stems of *Hevea brasiliensis.* Not described.

PETCH, T.—Continued.
1923. Report of the work of the division of botany and mycology. *In* Ann. Rpt. Ceylon Dept. Agr. 1922, p. D17–D18.
Root diseases of Hevea caused by *Xylaria thwaitesii* and *Fomes lucidus*. "One case was reported in which *Polyporus mesotalpae*, which is known to cause root disease in tea, was associated with a Hevea."

1923. A root disease of Hevea (Xylaria thwaitesii Cooke). *In* Trop. Agr., v. 60, p. 100–101, illus.

1924. Thread blights. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 9, p. 1–45, illus.
Malayan thread-blight on Hevea. p. 27–28. On stems and leaves. Malaya, Sumatra. "This species does not appear to cause damage to woody stems, as far as the available specimens show, but it kills the leaves when it runs over them." Fructification unknown. White stem blight on Hevea, etc., p. 29–31. Ceylon.

1925. Additions to Ceylon fungi. III. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 9, p. 313–328.
Sebacina rufochracea v. Hohnel in litt., n. sp., recorded from Mariawatte, Ceylon.

1925. Notes on Ceylon Thelephoraceæ, etc. *In* Ann. Roy. Bot. Gard. Peradeniya, v. 9, p. 259–298.
Corticium emplastrum B. and Br. recorded as common on dead branches of Hevea; also *Peniophora decidua*, n. sp.

PETERS, L.
1912. Über eine Fruchtfäule von Hevea brasiliensis in Kamerun. *In* K. Biol. Anst. Land.-u Forstw. Mitt. 12 (Bericht 1911), p. 18–22.
Fruit rot caused by a species of Phytophthora. Other fungi and bacteria were found.

PINCHING, H. C.
1921. [Report on visit to Burma.] *In* Bul. Rubber Growers' Assoc., v. 3, p. 64–75.
Pests and diseases, p. 69–74. Several fungi listed.

1924. A consideration of the present condition of the earliest Hevea plantings in the East. *In* Rpt. Internat. Rubber Conf. Brussels, 1924, p. 166–180.

PLANTERS' ASSOCIATION OF CEYLON.
1905–24. Rubber industry. *In* Year Book Planters' Assoc. Ceylon. 1904–23.
No reference to pathology of rubber in reports before 1904. Report on fungous diseases under various titles; as, notes by Government Mycologist, Report of Mycological Division, etc.

PRATT, H. C.
1917. Apparent relation between height of tapping cut and black-thread attacks (Phytophthora faberi Maub.). *In* Trop. Agr., v. 49, p. 7.
The nearer the tapping cut is to the ground the more liable the tapping area is to attack.

1917. Preventive measures against black thread (Phytophthora faberi). *In* Agr. Bul. Fed. Malay States, v. 5, p. 180–182. Also in Trop. Agr., v. 48, p. 304–306, 1917.
Disease known as black-thread, stripe canker, or cambium rot. Progress of disease dependent upon wet weather and tapping. Daily disinfection with carbolineum recommended. Report is from Sumatra.

RANDS, R. D.
1919. De bruine binnenbastziekte van Hevea brasiliensis; voorloopige mededeeling. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 3, p. 156–159. Bibliography, p. 159. (Meded. Inst. Plantenziekten.)
English translation: Brown-bast disease of *Hevea brasiliensis;* preliminary account, p. 158–159. "It appears, therefore, that brown bast is an accentuated condition of gum secretion probably resulting from the response on the part of the tree to the present methods of tapping."

1919. Progress report on brown bast. *In* Publ. Nederland.-Ind. Landb. Synd., jaarg. 11, p. 385–387.

1920. Selectie van een zeer productief ras van Hevea, dat een groot weerstandsvermogen tegen bruine binnenbast-ziekte vertoont. . . . (With a summary in English). Meded. Inst. Plantenziekten Buitenzorg 42, 14 p. Also in Arch. Rubbercult. Nederland.-Indie, jaarg. 4, Alg. Gedeelte, p. A264–A274, 1920.
English summary has title: Selection of a high-yielding strain of Hevea resistant to brown bast.

1921. Brown bast of plantation rubber: Its cause and prevention. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 223–278, illus. Literature cited, p. 275–278. (Meded. Inst. Plantenziekten 47.)
Dutch resumé, p. 272–274. Gum secretion indicates disease to be of the nature of a wound response. Abstract in Rev. Appl. Mycol., v. 1, p. 137–140, 1922.

1921. Histological studies on the brown-bast disease of plantation rubber. Meded. Inst. Plantenziekten Buitenzorg 49, 27 p., illus. Literature cited, p. 26–27. Abstract in Rev. Appl. Mycol., v. 1, p. 140–142, 1922.
Brown-bast appears to represent an accentuated type of wound gum secretion probably resulting from response to overfrequent tapping. Affected bark is not killed, but is often more active than normal.

1924. South American leaf disease of Para rubber. U. S. Dept. Agr. Bul. 1286, 18 p., illus.

RANT, A.
1911. De djamoer-oepas-ziekte in het algemeen in bij kina in het bijzonder. Meded. Uitgaande Dept. Landb. 13, 38 p., illus.
Corticium javanicum reported on various hosts including *Hevea brasiliensis*.

1912. Ueber die djamoer-oepas-krankheit und ueber das Corticium javanicum Zimm. *In* Bul. Jard. Bot. Buitenzorg, ser. 2, no. 4, 50 p., illus. Bibliography, p. 47–48.
Reported on a large number of hosts, including *Hevea brasiliensis*, *Castilloa elastica*, and *Ficus elastica*. Results of culture and infection experiments are given. Reviewed by Petch in Trop. Agr., v. 39, p. 44–45, 1912; and in Planters' Chron., v. 7, p. 451–452. 1912.

REEVE, A. T.
1922. Report of division of plant pests and diseases inspection (southern). *In* Ceylon Dept. Agr. Rpt. 1922, p. 21–22.
Daldinia concentrica, *Fomes lignosus*, and *Ustulina zonata* found on rubber.

REHM, H.
1908. Ascomycetes exs. Fasc. 42. *In* Ann. Mycol., jahrg. 6, p. 485–491.
Phyllachora huberi on *Hevea brasiliensis* from Brazil.

REINKING, O. A.
1919. Host index of diseases of economic plants in the Philippines. *In* Philippine Agr., v. 8, p. 38–54.
Lists 21 fungi found on *Artocarpus integrifolia*, *Castilloa elastica*, *Hevea brasiliensis*, and *Manihot glaziovii*.

1919–1921. Higher basidiomycetes from the Philippines and their hosts. I–V. *In* Philippine Jour. Sci., v. 15, p. 479–490; 16, p. 167–179, 527–537; 17, p. 363–374; 19, p. 91–114.
Host index at end of each installment.

REYES, G. M.
1920. Storage-rots caused by Diplodia. *In* Philippine Agr., v. 8, p. 235–260. Bibliography, p. 259–260.
Brief references to Diplodia on Hevea, p. 237 and 238.

RICHARDS, R. M.
1917. Diseases of the leaves and stem of Hevea brasiliensis in the Malay Peninsula. *In* Agr. Bul. Fed. Malay States, v. 5, p. 307–317. Also in Proc. 1st Agr. Conf. Malaya, 1917, p. 44–54.
The most serious stem diseases recorded are those caused by *Corticium salmonicolor*, *Phytophthora faberi*, *Phytophthora* sp., and *Botryodiplodia theobromae*. Less serious diseases are caused by *Phyllostieta ramicola*, *Gloeosporium alborubrum*, *Cyphella heveae*, and burs. No important leaf diseases are reported.

——— and SUTCLIFFE, H.
1914. Hevea brasiliensis, the general structure of the tree, the arrangement of the latex-bearing system and its practical significance and the formation of burrs. Published by the Malay Penins. Agr. Assoc. [Not seen.]

RIDLEY, H. N.
1904. Knots on Para rubber trees. *In* Agr. Bul. Straits and Fed. Malay States, v. 3, p. 20–21.
The knots have no connection with any fungus, but are due to the irritation caused by suppressed buds in the stem.

1904. A leaf-fungus on Hevea brasiliensis. *In* Agr. Bul. Straits and Fed. Malay States, v. 3, p. 308–309.
"The fungus appears to be one of the Uredineæ and may prove a serious pest."

1904. Parasitic fungi on Hevea brasiliensis. *In* Agr. Bul. Straits and Fed. Malay States, v. 3, p. 173–175.
The first part is a review of Hennings, Ueber die auf Hevea-arten bisher beobackteten parasitischen Phze in Notizbl. K. Bot. Gartens u. Mus. Berlin, Bd. 4, p. 133–138, 1904. In addition, describes root disease caused by *Fomes semitostus* and an unidentified bark fungus.

1905. A bark fungus on Para rubber. *In* Agr. Bul. Straits and Fed. Malay States, v. 4, p. 423–424.
An unidentified fungus found on a closely planted tree, Malay Peninsula. Later identified as *Corticium calceum*. See Agr. Bul. Straits and Fed. Malay States, v. 5, p. 69, 1906.

1905. The canker of Para rubber. *In* Agr. Bul. Straits and Fed. Malay States, v. 4, p. 74–75.
The fungus causing the disease is a species of Nectria. Stem and branches are equally liable to attack, but the roots and twigs are unaffected. More common in Ceylon than on the Malay Peninsula.

1905. A fungus on Para rubber leaves. *In* Agr. Bul. Straits and Fed. Malay States, v. 4, p. 271–272.
Massee identified the fungus as being a species of Cercospora. Common all over the Malay Peninsula.

1905. Rubber in Africa. *In* Agr. Bul. Straits and Fed. Malay States, v. 4, p. 387–388.
Abstract of report by Johnson, director of agriculture, Gold Coast, on rubber planting. Mentions fact that Funtumia is attacked by Meliola. Original report not seen.

1906. A disease of rubber seedlings. *In* Agr. Bul. Straits and Fed. Malay States, v. 5, p. 400–401.
An unidentified fungous disease, attacking seedlings at the collar.

RIDLEY, H. N.—Continued.

1906. A fungus attacking roots of Para rubber. *In* Agr. Bul. Straits and Fed. Malay States, v. 5, p. 64–65.
Fungus can not be identified, as no sporophores have been found.

1906. Para rubber leaf fungus. *In* Agr. Bul. Straits and Fed. Malay States, v. 5, p. 68.
Petch sends a leaf fungus which he is about to describe under the name of *Helminthosporium heveae*. It appears to be identical with the fungus described in the bulletins on several occasions as attacking young leaves.

1907. Abnormalities in the stem of Hevea. *In* Agr. Bul. Straits and Fed. Malay States, v. 6, p. 157–160. illus.
Burs and wind twist. Includes a letter from P. J. Burgess on bur formation. Summary in Trop. Agr., v. 29 (sup.), p. 60, 1907; also in Planters' Chron., v. 2, p. 244–245, 1907.

1908. Some diseases of rubber plants. *In* Agr. Bul. Fed. Malay States, v. 7, p. 439–443.
Review of Bernard's article in Bul. Dept. Agr. Ind. Néerland, no. 12, pt. III. 1907.

1909. Another fungus parasite on rubber. *In* Agr. Bul. Straits and Fed. Malay States, v. 8, p. 312.
Hymenochaete noxia.

1909. A new fungus pest on Para rubber. *In* Agr. Bul. Straits and Fed. Malay States, v. 8, p. 310–312. Also in Trop. Agr., v. 33, p. 183–184, 1909.

1909. The black Hevea fungus. *In* Agr. Bul. Straits and Fed. Malay States, v. 8, p. 521, 570–571.
The fungus proves to be an undescribed species of Diplodia and will be described as *D. rapax.*

1910. Another Para rubber fungus. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 216–218. Also in Trop. Agr., v. 35, p. 77–78, 1910.
Eutypa caulivora, probably a true parasite, only comes to surface to produce fruit when host is dead.

1910. Corticium javanicum in Borneo. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 59–60.
Describes an attack of pink disease on an estate in Sarawak.

1910. Eutypa caulivora. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 460.
Quotes note by Massee in Kew, Roy. Bot. Gard. Bul. no. 7, 1910.

1910. Fomes semitostus. *In* Planters' Chron., v. 5, p. 435–437.
Lecture delivered in Singapore, August 20, 1910. Reprinted from Singapore Free Press, August 22, 1910.

1910. Progress in rubber cultivation in 1909. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 130–133.
Abstract of and comment on A retrospect of 1909, in India-Rubber Jour., v. 39, p. 39–53, 1910. Mentions two new diseases, *Diplodia rapax* and Hymenochaete.

1910. Rubber fungi. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 380–384.
Lecture at Agri-horticultural show, August, 1910. Discusses *Fomes semitostus* and Diplodia.

1910. Rubber notes. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 174–175.
Mentions *Diplodia rapax*, which was probably conveyed from Singapore to the Gold Coast on stumps.

1910. Two Para rubber fungi. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 461–463.
Hymenochaete noxia and *Sphaerostilbe repens.* Quotes Petch's articles in Circs. and Agr. Jour. Roy. Bot. Gard. Ceylon, v. 5, 1910, with comments on conditions on the Malay Peninsula.

1911. The chief diseases of Para rubber in Malaya and Ceylon. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 141–143.
Review of Vernet, Sur les principales maladies de l'Hevea dans la Peninsule Malaise, à Java, et à Ceylon. Discusses *Fomes semitostus* and *Corticium javanicum* and lists 16 other diseases. Ridley disagrees with Vernet's conclusions on Fomes.

1911. Eutypa as a parasite. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 6.
Previously considered a saprophyte, *Eutypa caulivora* now appears to be a parasite.

1911. Hevea disease in Ceylon. *In* Agr. Bul. Straits and Fed. Malay States, v. 10, p. 70–71.
Phytophthora faberi attacks both cacao and Para rubber. Diseased bark reddish purple, often with a well-defined black border, and in advanced cases exuding a purple-brown liquid when cracked.

——— and DERRY, R.

1910. Third report on experimental tapping of Para rubber trees in the Botanical Gardens, Singapore—continued. Pests. *In* Agr. Bul. Straits and Fed. Malay States, v. 9, p. 289–297.
Fomes semitostus, Diplodia rapax, Eutypa caulivora.

RINGOET.

1923. La culture de l'Hévéa à la station agricole de Yangambi Gazi (Province Orientale) durant l'exercise 1921. *In* Bul. Agr. Congo Belg., tome 14, p. 5–38.
Accidents et maladies, p. 8–9.

RIS, V.
1909. Bestrijding van de wortelschimmel bij Hevea met carbolineum. *In* Teysmannia, jaarg. 20, p. 577–581, illus.

ROBINSON, E. A.
1915. Hevea rubber cultivation and curing at Nonpareil Estate, Sangre Grande, Trinidad. *In* Bul. Dept. Agr. Trinidad and Tobago, v. 14, p. 118–119.
Estate reported singularly free from insect pests and diseases; only 5 cases of canker among 40,000 to 50,000 trees.

RORER, J. B.
1911. A preliminary list of Trinidad fungi. (In his Report of mycologist, 1910/11, pt. 2) Circ. Bd. Agr. Trinidad 4, p. 37–44.
Phytophthora faberi and *Phyllosticta heveae* found on Hevea. No description.

1917. The South American Hevea leaf disease. *In* Bul. Dept. Agr. Trinidad and Tobago, v. 16, p. 128–129.
Caused by a Scolecotrichum. The disease is not so virulent in Trinidad as in Surinam.

RUBBER GROWERS' ASSOCIATION, LONDON.
1922. Scientific research notes. *In* Bul. Rubber Growers' Assoc., v. 4, p. 107–110, 270–275, 321–324, 377–379, 453–455, 514–520, 584–590.
Brief mention is made of various Hevea diseases on the Malay Peninsula and in southern India.

RUTGERS, A. A. L.
1912–17. Hevea-kanker. Pt. I–III. (With a summary in English.) Meded. Inst. Plantenziekten Buitenzorg, 2, 4, and 28.
Both patch canker and stripe canker are caused by *Phytophtora faberi*. Found in Java, Sumatra, Borneo, Ceylon, and the Federated Malay States.

1913. Ziekten en plagen van Hevea in de Federated Malay States. *In* Meded. Inst. Plantenziekten Buitenzorg 4, p. 8–16.
Canker, *Fomes semitostus*, and burs.

1914–15. Ziekten en plagen der cultuurgewassen in Nederlandsch-Indie in 1913, 1914. Meded. Inst. Plantenziekten Buitenzorg 9 and 15.
See also Hall, C. J. J. van, Ziekten en plagen der cultuur-gewassen in Nederlandsch-Indie in 1915-date. in Meded. Inst. Plantenziekten Buitenzorg 20, 29, 33, 36, 39, 46, 53, 58.

1916. Bladziekte en kanker bij de Hevea. *In* Indische Mercuur, jaarg. 39, p. 1120.
Lecture before the Rubberplanters-vereeniging at Bandoeng. Gives general descriptions of diseases without mentioning names of fungi. States that the cause of the South American leaf disease has been identified as *Melanopsammopsis heveae*.

1916. Nieuwe waarnemingen omtrent zaadziekte en kanker bij Hevea. *In* Alg. Ver. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915/16, p. 63–66.
Phytophthora faberi.

1917. Bestrijding van streepkanker (black-thread disease). Circ. Proefstat. Malang (Middle Java) 5, 2 p.

1917. Hevea-kanker. *In* Arch. Rubbercult. Nederland.-Indie, v. 1, p. 149–156. English summary, p. 152–156.
Summary of Meded. Lab. Plantenziekten no. 26, Dept. Landb. Nijverh. en Hand.

1917. Phytopathologische aanteekeningen. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 1, p. 313–317. (Meded. Alg. Proefstat. A. V. R. O. S. Rubberserie no. 4.)
Discusses *Ustulina zonata*, Poria, scaly-bark, leaf diseases, horsehair blight, and lightning injury.

1917. Rubber-bibliographie, 1910–16. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 1, p. 451–528. (Meded. Alg. Proefstat. A. V. R. O. S. Rubberserie no. 5.)

1918. Bastziekten in de F. M. S. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 2, p. 57–59.
Summary of several papers which appeared in Malayan Tin and Rubber Jour., Aug., Sept., and Oct., 1917.

1918. Voorschriften voor de bestrijding van bastziekten bij Hevea. Instructions for the combating of bark disease in Hevea (issued by the General Experiment Station of the A. V. R. O. S., October, 1917). *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 2, p. 55–57.

1919. Bliksemschade bij Hevea. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 3, p. 163–171, illus. (Meded. Alg. Proefstat. A. V. R. O. S. Rubberserie no. 18.)
English summary: The effect of lightning on Hevea, p. 171. Four types of injury are described, of each of which a number of cases were found by the author in Sumatra.

——— and ARENS, P.
1914. Diseases of Hevea brasiliensis in Java. *In* Internat. Rubber Cong. and Exhib. Batavia, 1914, Rubber Rec., p. 130–139, illus. Literature, p. 138–139.
Gives symptoms and treatment of all important diseases.

——— and DAMMERMAN, K. W.
1914. Ziekten en beschadigingen van Hevea brasiliensis op Java. Meded. Inst. Plantenziekten Buitenzorg 10, 45 p. illus. References at end of each section.
Diseases of roots, branches, stems, and leaves; injuries and abnormalities.

RYCKMAN, A. DE.
1909. Note sur la ramification de l'Hévéa par la taille et par l'effeuillage. *In* Jour. Agr. Trop., ann. 9, p. 5–7.
Mention is made of *Corticium javanicum* Zimm.

SACCARDO, P. A.
1921. Fungi singaporenses Bakeriani. (Notae mycologicae, ser. XXIV.) *In* Bul. Ist. Orf. Bot. Napoli, tomo 6, p. 39–65.
Descriptions of fungi listed in Baker, Fungi from Singapore, in Gard. Bul. Straits Settlements, v. 2, p. 116–120, 1919. (This article dated 1918; date of imprint of volume, 1921.)

SANDERSON, A. R.
1921. Some aspects of root diseases of Hevea brasiliensis. *In* India-Rubber Jour., v. 61, p. 1227–1228.
Names seven species of fungi which have already been recorded in the Malay Peninsula as the causative agents of root diseases.

1922. Brown bast. *In* Bul. Rubber Growers' Assoc., v. 4, p. 380–381.
"The total loss in revenue per annum is in some cases very high, and unless steps are taken to check the increase in percentage cases the loss must be increasing annually."

——— and SUTCLIFFE, H.
1920. Sphaeronema sp. (Mouldy rot of the tapped surface.) *In* Ann. Appl. Biol., v. 7, p. 56–65, illus.
Report of cultural and inoculation experiments which show that moldy rot is caused by a species of Sphaeronema and not by Cephalosporium or Fusarium.

1921. Brown bast: an investigation into its causes and methods of treatment. 71 p., illus. London. References, p. 66.
"Considering, as we do, that brown bast is physiological in origin, it must be regarded in the first instance rather as an abnormality than a disease, though one state may lead to the other, owing to interference with the functions of a portion of the tissue." Abstract in Rev. Appl. Mycol., v. 1, p. 142–144, 1922.

SANDMAN, D.
1911. Feeding-up rubber trees the best preventive against root-fungus (Fomes semitosus). *In* Planters' Chron., v. 6, p. 20–21.
Quoted from his brochure on the dangers, mistakes, and improvements connected with the production of rubber in Asia.

SANDS, W. N.
1924. Mistletoes attacking cultivated trees in Malaya. *In* Malayan Agr. Jour., v. 12, p. 64–76, illus. Literature cited, p. 75.
Descriptions of the five chief species are given. Three of these (*Loranthus ferrugineus, L. pentandrus,* and *Elytranthe globosa*) are found on *Hevea brasiliensis.*

SCHRIEKE, G. G.
1922. Het rubberbedrijf op het Schiereiland Malacca. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 339–367.
The following diseases were reported: Brown-bast, Fomes, Ustulina, Poria, moldy rot.

1922. The rubber industry in the Malay Peninsula. *In* Bul. Rubber Growers' Assoc., v. 4, p. 434–448.
Brown-bast, Fomes, Ustulina, Poria, moldy rot, and pink disease mentioned under "Pests and diseases."

SCHURZ, W. L., HARGIS, O. D., MARBUT, C. F., and MANIFOLD, C. B.
1925. Rubber production in the Amazon Valley. U. S. Dept. Com., Trade Promotion Ser. no. 23, 369 p., illus.
Mentions disease of Hevea and refers to this bulletin for detailed information.

SHARPLES, A.
1914. The spotting of prepared plantation rubber. Bul. Dept. Agr. Fed. Malay States 19, 31 p., illus. Literature cited, p. 30–31.
Continuation of investigations of Bancroft reported in Dept. Agr. Fed. Malay States Bul. 16, 1913. Disagrees with Bancroft's conclusions as to organisms causing spotting.

1915. Bark scraping and bark affections. *In* Agr. Bul. Fed. Malay States, v. 3, p. 420–425.
First bark disease noticed on the Malay Peninsula. Trees showed slow rotting of bark, over which numerous saprophytic fungi grew. Bark appeared water-logged and borers entered as rotting proceeded. Trees affected had been scraped to increase flow of latex.

1915. Bordeaux mixture as a spray for rubber trees. *In* Agr. Bul. Fed. Malay States, v. 3, p. 447–448.
"There is little danger in using Bordeaux mixture as a spray against the attacks of fungi on rubber trees."

1915. Host plants of pink disease in Malaya. *In* Agr. Bul. Fed. Malay States, v. 3, p. 203–204.
Adds three new hosts to list of Brooks and Sharples in Bul. 21, Dept. Agr. Fed. Malay States, 1914. *Tephrosia hookeriana* acted as center of infection on rubber estate.

1915. Spottings in plantation rubber due to fungi. *In* Trans. 3d Internat. Cong. Trop. Agr., London, 1914, v. 1, p. 679–687. Bibliography, p. 687.
Defects of prepared rubber due to fungi are distinguished as spottings where discolored area is small and flushes where there is a broad patch of colored rubber. Describes yellow flush, violet flush, black spots, and blue-black spotting. Shows that undiluted latex is an unfavorable growing medium for fungi.

SHARPLES, A.—Continued.

1916. The laticiferous system of Hevea brasiliensis and its protective function. *In* Ann. Bot., v. 32, p. 247–251.
Heavy scraping of the bark results in increased growth of saprophytic fungi.

1916. Scorched trees and their treatment. *In* Agr. Bul. Fed. Malay States, v. 5, p. 1–2. Also in Trop. Agr., v. 48, p. 56–57, 1917.
If left untreated, boring beetles enter the tree through the scorched surfaces. The insects are followed by the fungus *Ustulina zonata*.

1916. Ustulina zonata; preliminary report on further work. *In* Agr. Bul. Fed. Malay States, v. 4, p. 98–105.
In continuation of Bul. 22, Dept. Agr. Fed. Malay States, 1915, by F. T. Brooks. Appears to be a wound parasite, usually entering through wounds in exposed lateral roots. Almost always found in trees attacked by boring beetles.

1916. Ustulina zonata—a fungus affecting Hevea brasiliensis. Bul. Dept. Agr. Fed. Malay States 25, 27 p., illus.
A wound parasite, causing dry-root and collar rot. Article contains history, field observations, description of the fungus, culture experiments, inoculation experiments, and treatment. Summary by W. Nowell in Agr. News [Barbados], v. 15, p. 318, 1916.

1917. Bark canker in Hevea brasiliensis. *In* Kew, Roy. Bot. Gard. Bul. 1917, p. 219–225. Bibliography, p. 225.
Résumé of previous work by Rorer, Rutgers, Petch, Dastur, and others.

1917. The significance of diseases in the economy of Malayan rubber plantations. *In* Kew, Roy. Bot. Gard. Bul. 1917, p. 225–229.
A summary of the investigations of diseases of *Hevea brasiliensis* on the Malay Peninsula from 1913 to 1917.

1918. Ustulina zonata (Lev.) Sacc. on Hevea brasiliensis. *In* Ann. Appl. Biol., v. 4, p. 153–178, illus. Bibliography, p. 177.
Deals with the dry collar-rot on old rubber caused by *Ustulina zonata*. Disease is common on the Malay Peninsula and in Ceylon, but not yet reported in Java or Sumatra.

1921. Estate treatment of mouldy rot. *In* Agr. Bul. Fed. Malay States, v. 9, p. 277–278.
Abstract of a letter received from an estate manager on the suggestion of the mycologist, in order to obtain a reliable estimate of costs of treatment of moldy rot with agrisol.

1921. Treatment of mouldy rot disease by application of agrisol. *In* Agr. Bul. Fed. Malay States, v. 9, p. 184–191.
Describes successful treatment of moldy rot with a proprietary coal-tar disinfectant.

1922. A consideration of recent work on the brown bast problem. *In* Malayan Agr. Jour., v. 10, p. 155–170.
Comparative résumé of work done by the Brown Bast Investigation Committee on the Malay Peninsula and by Rands in Java. Both arrive at the conclusion that the disease is noninfectious and is probably induced by overtapping. Abstract in Rev. Appl. Mycol., v. 2, p. 232–233, 1923.

1922. A preliminary account of observations on the fungi causing "brown root" disease. *In* Malayan Agr. Jour., v. 10, p. 181–183.
Shows that fungi causing the brown root differ on different hosts and in different countries.

1923. Annual report of the mycologist for 1922. *In* Malayan Agr. Jour., v. 11, p. 267–272.
Rubber root diseases, brown-bast, moldy rot, etc., p. 267–269.

1923. Final report on treatment of mouldy rot disease with agrisol. *In* Malayan Agr. Jour., v. 11, p. 36–37.
The production of resting spores by the causal fungus (*Sphaeronema fimbriatum*) makes complete eradication impossible.

1923. Report on black fruit disease of pepper vines in Sarawak. *In* Malayan Agr. Jour., v. 11, p. 123.
Refers to *Cephaleuros mycoidea* (Karst.) on Hevea.

1924. Some observations on root diseases of Hevea brasiliensis. *In* Malayan Agr. Jour., v. 12, p. 404–407. Also in Planters' Chron., v. 20, p. 90–93, 1925.
Questions the proof that *Ganoderma ferreum* and *Fomes pseudoferreus* are identical, also that *Fomes lamaoensis* is the cause of brown root-rot with cultural evidence. Variability of *Ustulina zonata* emphasized.

1925. Annual report of the mycologist for 1924. *In* Malayan Agr. Jour., v. 13, p. 214–219. Rubber diseases, p. 214–216.

1925. Brown bast disease of rubber trees. *In* Rpt. Proc. Imp. Bot. Conf. London, 1924, p. 163–170. Also printed in Trop. Agr., v. 64, p. 323–328, 1925.
"After three years' experimental work in the field, the view is advanced that the affection is a purely physiological disturbance resulting from the extraction of excessive quantities of latex."

1925. A collar disease of rubber seedlings. *In* Malayan Agr. Jour., v. 13, p. 150–153.
Due to *Diplodia* sp. A similar disease reported from Java and Ceylon is attributed to *Pestalozzia palmarum*, no trace of which was found in the diseased Malayan seedlings. Abrupt changes in climatic conditions, combined with the presence of a fungus, may possibly account for the trouble.

SHARPLES, A. and BELGRAVE, W. N. C.
1917. Memorandum recommending clean clearing of rubber estates in Malaya. *In* Agr. Bul. Fed. Malay States, v. 6, p. 81–91.
Clean clearing is recommended as preventing attacks of root diseases, particularly *Poria hypolaterita* and *Ustulina zonata*.

——— and OTHERS.
1920. Black stripe and mouldy rot of Hevea brasiliensis. Bul. Dept. Agr. Fed. Malay States 31, 61 p., illus. Bibliography of black stripe, p. 60.
A species of Phytophthora was isolated which is believed to be the cause of black-stripe canker. Moldy rot, a disease of recently tapped surface, is found to be caused by *Sphaeronema fimbriatum*. Summary in Trop. Agr., v. 55, p. 373–379, 1920, quoted from Malayan Tin and Rubber Jour., v. 9, no. 19.

——— and LAMBOURNE, J.
1923. Preliminary report on brown bast experiments in Malaya. *In* Malayan Agr. Jour., v. 11, p. 30–35. Also in Trop. Agr., v. 60, p. 360–364, 1923.
Reports on tapping experiments in relation to brown-bast and observations on the resistance of bud grafts to disease.

1924. Field experiments relating to brown bast disease of Hevea brasiliensis. *In* Malayan Agr. Jour., v. 12, p. 290–343.
Evidence obtained from prolonged tapping experiments is strongly in favor of the physiological origin of brown-bast.

SHAW, F. J. F.
1919. Economic botany. III. Mycology. *In* Ann. Rpt. Bd. Sci. Advice India, 1917–18, p. 35–40.
Investigations on black-thread disease reported.

SHELTON-AGAR, W. R.
1917. Clean clearing, pests and diseases. *In* Agr. Bul. Fed. Malay States, v. 5, p. 300–306. Also in Proc. Agr. Conf. Malaya, 1st, 1917, p. 37–43.
Divides diseases into two classes, fatal and amenable to treatment. Fatal include all root diseases; amenable, stem and bark diseases. Gives recommended treatment of diseases but no descriptions.

SIMMONDS, H. W.
1921. A bacterial disease of Para rubber. *In* Circ. Dept. Agr. Fiji Isl., v. 2, p. 45.
Bark rough and stained reddish brown. Does not seem to be highly infective. See also Carment, A bacterial disease of rubber trees. *In* Circ. Dept. Agr. Fiji Isl., v. 2, p. 46, 1921. Abstract in Rev. Appl. Mycol., v. 1, p. 39, 1922.

SIMPSON, S.
1916. Annual report of the government botanist (based on work of T. D. Maitland, with notes added by W. Small). *In* Ann. Rpt. Dept. Agr. Uganda, 1916, p. 44–47.
Diseases of Hevea mentioned: Die-back (*Lasiodiplodia theobromae*); root diseases (*Hymenochaete noxia?, Fomes lucidus?, Fomes australis?*).

SMALL, W.
1914. Report by the botanist. *In* Ann. Rpt. Dept. Agr. Uganda, 1914, p. 59–62.
Brown root disease (*Hymenochaete noxia*); canker (*Phytophthora faberi*); die-back (*Gloeosporium alborubrum, Phyllosticta ramicola,* and *Thyridaria tarda*); fasciation.

1915. Annual report of the government botanist for 1914–1915. *In* Ann. Rpt. Dept. Agr. Uganda, 1915, p. 57–70.
Diseases of Para rubber enumerated include: *Hymenochaete noxia, Thyridaria tarda, Phyllostieta ramicola,* and *Phoma heveae* (p. 67–68).

1920. Diseases of Hevea brasiliensis in Uganda. Circ. Dept. Agr. Uganda 3, 12 p.
Arranged according to part of tree attacked. Mentions diseases found in other regions but not yet appearing in Uganda.

1921. Notes on species of Colletotrichum and Phoma in Uganda. *In* Kew, Roy. Bot. Gard. Bul., 1921, p. 57–67. Abstract in Rev. Appl. Mycol., v. 1, p. 3–6, 1922.

1922–24. Annual report of the Government mycologist, 1921–1922. *In* Ann. Rpt. Dept. Agr. Uganda, 1921, p. 49–53; 1922, p. 27–29.

SMITH, E.
1908. Report on diseased rubber trees forwarded from Puak. *In* Agr. Bul. Straits and Fed. Malay States, v. 7, p. 90–92.
A bark disease caused by a fungus resembling Helicobasidium. A sporiferous bacillus was also isolated.

SMITH, H. H.
1911. Notes on soil and plant sanitation on cacao and rubber estates. 632 p., illus. London. Rubber diseases, p. 335–358.

SNOWDEN, J. D.
1921. Report of the Government botanist . . . 1st April to 31st December, 1920. *In* Ann. Rpt. Dept. Agr. Uganda, 1920, p. 43–46.
Diseases of Hevea rubber: p. 43–44. Lists briefly 14 fungi. Abstract in Rev. Appl. Mycol., v. 1, p. 206, 1922.

SÖHNGEN, N. L., and FOL, J. G.
1914. Die Zersetzung des Kautschuks durch Mikroben. *In* Centbl. Bakt., Abt. 2, Bd. 40, p. 87–98, illus.
Bacteria and molds on prepared rubber.

SOUTH, F. W.
1911–12. Report on the prevalence of some pests and diseases in the West Indies. Fungus diseases, 1909/10, 1910/11. *In* West Indian Bul., v. 11, p. 73–85; 12, p. 425–443. See also Ballou, H. A. Report . . . 1912. Nowell, W. Report . . . 1913.

SOUTH, F. W.—Continued.

1912. Fungus diseases of cacao. *In* West Indian Bul., v. 12, p. 277–302. List of references, p. 300–302.
Includes several diseases which are found on both Hevea and cacao. See also Abstract of proceedings, in West Indian Bul., v. 12, p. 142–145.

1912. Some root diseases of permanent crops in the West Indies. *In* West Indian Bul., v. 12, p. 479–498. Bibliography, p. 496–497.
Discusses white root disease; Thyridaria root disease; black root disease, due to Rosellinia; red root disease, caused by Sphaerostilbe; and lime root canker. Most of the instances of root diseases on rubber plants are quoted from authors in other countries.

1915. Notes on the distribution and field treatment of pink disease. *In* Agr. Bul. Fed. Malay States, v. 4, p. 47–58.
Gives details of treatment recommended and enforced by the Agricultural inspection staff.

1917. Application of the agricultural pests enactment. *In* Agr. Bul. Fed. Malay States, v. 5, p. 349–357. Also in Proc. Agr. Conf. Malaya, 1st, 1917, p. 86–94.
Discusses treatment of pink disease, black-stripe disease, and *Ustulina zonata*.

1918. Buried coconut trunks and root diseases of rubber. *In* Agr. Bul. Fed. Malay States, v. 6, p. 269.
Hymenochaete noxia and *Poria hypolateritia* spread from buried coconut trunks to roots of rubber trees in the case cited. Summary by E. D. Wildeman in Bul. Agr. Inst. Sci. Indochine, v. 2, p. 53–54, 1920.

1918. Revised distribution of pink disease by mukims. *In* Agr. Bul. Fed. Malay States, v. 6, p. 389–394.
See also anonymous list in Agr. Bul. Fed. Malay States, v. 5, p. 10–13, 1916.

1920. Certain host plants of Fomes lignosus and Ustulina zonata. *In* Agr. Bul. Fed. Malay States, v. 8, p. 242–243.
Fomes lignosus on bamboo stumps and rubber; *Ustulina zonata* on *Areca catechu*.

1920–24. Work of the inspection staff. *In* Agr. Bul. Fed. Malay States, v. 8, p. 111–112, 256–258; 9, p. 29–33, 155–158, 201–203, 284–289; Malayan Agr. Jour., v. 10, p. 106–111, 195–199, 264–268; 11, p. 89–96; 12, p. 32–50.
Title varies slightly. Semiannual, 1920; quarterly, 1921 to date. See also 1918 by A. G. G. Ellis.

1921. Distribution of pink disease in Federated Malay States mukims, 1920. *In* Agr. Bul. Fed. Malay States, v. 9, p. 279.
Reports show general improvement.

1923. Annual report of the chief agricultural inspector for 1922. *In* Malayan Agr. Jour., v. 11, p. 242–262.
Diseases and pests of rubber, p. 244–248. Pink disease, moldy rot and root diseases.

1924. Mouldy rot of rubber. *In* Trop. Agr., v. 63, p. 149–152.
Account taken from a lecture published in the Malayan Tin and Rubber Journal, v. 13, no. 14, p. 852–855, 1924.
Thick mold on bark consists of a mixture of two fungi, *Sphaeronema fimbriatum*, the cause of the disease, and *Cephalosporium* sp., mainly living on the dead or dying tissue.

1925. Annual report of the chief field officer, 1924. IV. Diseases and pests. *In* Malayan Agr. Jour., v. 13, p. 197–201. Rubber diseases, p. 197–198.

STAHEL, G.

1915. De Hevea-bladziekte van zuid-amerika. Meded. Dept. Landb. Surinam 1, 3 p.
Names the perfect stage *Melanopsammopsis heveae*.

1916. Over de bestrijding der zuid-amerikaansche Hevea-bladziekte. Meded. Dept. Landb. Surinam 6, 2 p. Also in Indische Mercuur, jaarg. 39, p. 986–987, 1916. (Same article repeated, p. 1149–1150, 1916.) Eng. translation: The control of the South American Hevea leaf disease, in Trop. Agr., v. 47, p. 369–370, 1916.

1917. De zuid-amerikaansche Hevea-bladziekte veroorzaakt door Melanopsammopsis ulei, nov. gen. (=Dothidella ulei P. Hennings). Bul. Dept. Landb. Surinam 34. 111 p., illus.

1919. De zuid-amerikaansche Hevea-bladziekte op de rubber-plantage der "Lawa Caoutchouc Compagnie." *In* West-Indie Landb. Tijdschr. Surinam en Curaçao, jaarg. 4, p. 63–64.

STEINMANN, A.

1921. Over den invloed van teer op de regeneratie van den bast bij Hevea brasiliensis. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 495–503, illus. Reviewed by Bobilioff in Teysmannia, jaarg. 32, p. 467, 1921.

1921. Over een abnormaliteit in den groei bij jonge Hevea-oculaties. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 5, p. 66–70, illus.

1922. Over de instervingsziekte bij Hevea brasiliensis. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 6, p. 93–112, illus. Bibliography, p. 107–109. (Mededeelingen van het Rubberproefstation "West-Java"). English summary: An apparently nonparasitic die-back of Hevea brasiliensis, p. 110–112.
Includes "Notes on the biology of *Gloeosporium alborubrum* Petch," indicating its identity with *G. elasticae*.

STEINMANN, A.—Continued.
1923. Aanvullende mededeeling over het optreden van Ustulina bij Hevea brasiliensis in Java. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 7, p. 448–452, illus. Bibliography, p. 452. (Mededeelingen van het Rubberproefstation "West-Java"-Phytopathologische serie no. 1, pt. 3.)
English summary: Some observations on the occurrence of Ustulina on rubber trees in Java, p. 463–465. Confirms Petch's conclusions as to the identity of *U. zonata* with *U. vulgaris*.

1923. Over eene ziekte van op de kweekbedden staande Hevea-zaailingen. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 7, p. 444–445, illus. (Mededeelingen van het Rubberproefstation "West-Java." Phytopathologische serie no. 1, pt. 1.)
English summary: On the occurrence of a nonparasitic disease of Hevea seedlings on nurseries, p. 461. The disease, which was at first wrongly attributed to *Pestalozzia palmarum*, is due to sunburn.

1923. Over de regeneratie van tegen bruinen binnenbast geschilden Heveabast. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 7, p. 153–167, illus. Bibliography, p. 164–165. (Mededeelingen van het Rubberproefstation "West-Java").
English summary: On the renewal of Hevea bark after peeling, p. 166–167.

1924. Enkele mededeelingen over twee in Java tot nu toe minder bekende wortelschimmels bij Hevea brasiliensis. (Phytopathologische ser. no. II, 3.) *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 8, p. 138–140, illus. English summary, p. 143–144.
Reports cases of blackroot disease (Rosellinia) and *Sphaerostilbe repens*.

1924. Korte aanteekeningen omtrent Ustulina. (Phytopathologische ser. no. II, 4.) *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 8, p. 140. English summary, p. 144.
"In connection with our previous paper where we pointed out the identity of the *Ustulina zonata* (Lev.) Sacc. from Java with the *Ustulina vulgaris* Tul. . . . we have made a more detailed study of this matter . . . By reason of priority we came to the conclusion that the species in question ought to be called *Ustulina maxima* (Weber) v. Wettstein."

1924. Over een heksenbezem bij Hevea brasiliensis. (Phytopathologische serie no. II, 1.) *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 8, p. 130–134. Bibliography, p. 133–134. English summary, p. 141.
"The cause of this abnormal development may be attributed to the stimulus of an intracellular fungus, the mycelium of which is found principally in the tissues of the pith. As the fructifications have up to now not been found, we are unable as yet to identify the fungus."

1925. De ziekten en plagen van Hevea brasiliensis in Nederlandsch-Indie. 146 p., illus. Buitenzorg.

——— and BERNARD, C.
1925. De luizenschimmel van Hevea, Hypocrella Reineckiana P. Henn. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 9, p. 515–517, illus. English, p. 525.
On leaves and stalks. Dutch East Indies. Does not injure the tree, but contributes to destroying noxious insects.

STEVENS, F. L.
1913. The fungi which cause plant disease. 754 p., illus. New York.
Various fungi listed on Hevea.

——— and HALL, J. G.
1921. Diseases of economic plants. 507 p., illus. New York.
Diseases of rubber mentioned are "Cankers due to various species of Nectria, Corticium, Fusicladium, and Diplodia; die-back (Thyridaria) which kills the young shoots; seedling diseases due to Pestalozzia, Helminthosporium, and numerous leaf fungi, and root-rot due to Fomes, Irpex, Hymenochaete, and Poria."

STEVENS, H. P.
1921. The effect of mould on the properties of sheet rubber. (Report by the consulting chemist in London.) *In* Bul. Rubber Growers' Assoc., v. 3, p. 190–191.

1921. Mould on sheet rubber. (Report of the consulting chemist in London.) *In* Bul. Rubber Growers' Assoc. v. 3, p. 243–245.

1921. Mouldy sheet and the effect of mould on quality. (Report by the consulting chemist in London.) *In* Bul. Rubber Growers' Assoc., v. 3, p. 97–98.

1921. The treatment of mouldy sheets and its effects on the vulcanizing properties. (Report of the consulting chemist in London.) *In* Bul. Rubber Growers' Assoc., v. 3, p. 472–473.

1922. Keeping qualities of rubber prepared with sodium silicofluoride. *In* Bul. Rubber Growers' Assoc., v. 4, p. 591–592.
Rubber prepared with sodium silicofluoride is satisfactory under aging tests.

1922. Modified application of sodium silicofluoride. *In* Bul. Rubber Growers' Assoc. v. 4, p. 592–593.
Experiments in the use of sodium silicofluoride as a mold preventive.

1922. Mould prevention. *In* Bul. Rubber Growers' Assoc., v. 4, p. 132–133.
Sodium silicofluoride recommended as an inexpensive and effective preservative.

1922. Sodium silicofluoride as a mould preventive. *In* Bul. Rubber Growers' Assoc. v. 4, p. 227–228.

STEVENS, N.
1925. Planters and scientists. Their proper relationship on rubber estates. *In* India-Rubber Jour., v. 70, no. 13a, p. 21–24, 1925. (Internat. Extra Number.)
Article showing the necessity of mycological study, disease control, and the large rôle the plant pathologist plays in the successful cultivation of rubber.

STOCKDALE, F. A.
1911. Report of the botanical division. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana, 1910–11, p. 23–43.
Diplodia cacaoicola recorded on *Hevea brasiliensis*. Possibly synonymous with *Botryodiplodia elasticae* and *Diplodia rapax*, associated with die-back of Hevea in the East.

SUNDARARAMAN, S.
1920. Our invisible crop enemies. *In* Planters' Chron., v. 15, p. 888–892.
Mentions leaf-fall on Hevea rubber. Madras.

—— and THOMAS, K. M.
1924. Some of the Diplodias found in southern India. *In* Agr. Dept. Madras Yearbook, 1922, p. 32–38.
Records a Diplodia found on the bark of dead branches of *Hevea brasiliensis*. Travancore.

SWART, N. L.
1917. Eenige opmerkingen naar aanleiding van ondernemingsbezoeken en de in 1916 door het Proefstation uitgebrachte adviezen. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 1, p. 42–51. (Mededeelingen van het Rubberproefstation "West-Java.")

1918. Een en andes over Hevea-ziekten. *In* Pub. Nederland.-Ind. Landb. Synd., jaarg. 10, p. 362–377.
General discussion on diseases of Hevea.

——— and RUTGERS, A. A. L.
1921. Handboek voor de rubbercultuur in Nederlandsch-Indie. 777 p., illus. Amsterdam.
Ziekten en plagen en hare bestrijding, p. 158–229.

SYDOW, H.
1923. Ein neuer Beitrag zur Kenntnis der Pilzflora der Philippinen-Inseln. *In* Ann. Mycol., jahrg. 21, p. 93–106.
Auerswaldia examinans (Mont. and Berk.) Sacc., and *Lasiodiplodia theobromae* (Pat.) Griff. and Maubl. recorded on Hevea.

——— SYDOW, P., and BUTLER, E. J.
1911. Fungi Indiae orientalis, pt. III. *In* Ann. Mycol., jahrg. 9, p. 372–421, illus.
Nectria diversispora on *Hevea brasiliensis; Phyllachora repens* on *Ficus religiosa*.

TERRY, H. L.
1907. India rubber and its manufacture. 294 p., illus. London.

THEISSEN, F., and SYDOW, H.
1915. Die Dothideales. Kritisch-systematische Originaluntersuchungen. *In* Ann. Mycol., jahrg. 13, p. 149–746.

THOMPSON, A.
1923. Mouldy rot: some suggestions for treatment. *In* Planters' Chron., v. 18, p. 153–157.

1924. A preliminary note on a new bark disease of Hevea. *In* Malayan Agr. Jour., v. 12, p. 163–164.
Fungus (unnamed) which has been observed to grow superficially on young bark becomes parasitic.

1925. A preliminary note on a Phytophthora associated with patch canker on Hevea brasiliensis in Malaya. *In* Malayan Agr. Jour., v. 13, p. 139–141.
Cause of patch canker, but organism different from *P. faberi*.

TROMP DE HAAS, W. R. T., and HALL, C. J. J. VAN.
1914. Review of Para rubber culture in Java. *In* Internat. Rubber Cong. and Exhib. Batavia, 1914, Rubber Rec., p. 185–201.
"Diseases and pests," p. 195. Most frequently occurring disease in Java is canker. Others are pink disease, white root disease, and brown root disease.

ULE, E.
1905. Kautschukgewinnung und Kautschukhandel am Amazonenstrome. *In* Tropenpflanzer Beihefte, Bd. 6, p. 1–71, illus.
Gives description of 13 species of Hevea and other rubber-producing plants found on the Amazon and lists several species of fungi growing on Hevea.

1907. Beiträge zur Flora der Hylaea nach den Sammlungen von Ule's Amazonas-Expedition. II. *In* Verhandl. Bot. Ver. Brandenb., jahrg. 48 (1906), p. 117–208.
Among the Loranthaceae is listed *Dendrophthora poeppigii* parasitic on *Hevea brasiliensis*.

ULTEE, A. J.
1922. Abnormale Heveabladeren. *In* Teysmannia, jaarg. 33, p. 45–46, illus.

URBAN, I.
1898. Additamenta ad cognitionem florae Indiae occidentalis. *In* Bot. Jahrb. [Engler], Bd. 24, p. 59.
Revised description of *Dendrophthora poeppigii* V. Tiegh.

VAN TIEGHEM, P.
1896. Sur le groupement des expèces en genres dans les ginalloées, bifariées, phoradendrées et viscées, quatre tribus de la famille des Loranthacées. *In* Bul. Soc. Bot. France, tome 43, p. 161–194.
Apparently original description of *Dendrophthora poeppigii* V. Tiegh., p. 182.

VERMOESEN, F. M. C.
1914. À propos des maladies cryptogamiques des Hévéas dans les plantations de Bakusu (Coquilhatville), District de l'Équateur. *In* Bul. Agr. Congo Belg., v. 5, p. 312–321.
Found no cases of root disease. Die-back (*Diplodia cacaoicola*) the only important disease; others noted were: *Hypocrella* sp., *Gloeosporium* sp., and *Hysterium* sp.

VINCENS, F.
1915. Contribution à l'étude des maladies de l'Hévéa brasiliensis dans la vallée de l'Amazone. *In* Bul. Soc. Path. Veg. France, tome 2, p. 11–27, 54–63, illus.
I. Maladies des feuilles. II. Maladies des tiges. New species: *Scolecotrichum heveae, Fusarium heveae, Zygosporium paraense, Cercospora heveae, Meliola heveae.*

1919. Maladies de l'Hévéa dues au Diplodia. *In* Bul. Agr. Inst. Sci. Saigon, ann. 1, p. 321–329.
Discussion of Diplodia and related or associated fungi as the cause of die-back and other diseases. Though Diplodia is not generally a root parasite, it occasionally attacks the roots of old trees.

1920. Maladie rose et chancre des branches sur Hévéa brasiliensis dûs au Corticium salmonicolor B. et Br. *In* Bul. Agr. Inst. Sci. Saigon, ann. 2, p. 321–331. Bibliography, p. 331.
Description of pink disease (*Corticium salmonicolor*) with suggestions for treatment. Said to be the most serious disease of Hevea in Indo China.

1920. Sur les formations lifneuses anormales dans l'écorce de l'Hévéa brasiliensis. *In* Compt. Rend. Acad. Sci. [Paris], tome 171, p. 871–873. Also in Bul. Agr. Inst. Sci. Saigon, ann. 3, p. 29–31, 1921.
Not due to infection by *Phytophthora faberi.*

1921. Rapport sommaire sur les travaux effectués au laboratoire de phytopathologie de l'Institut Scientifique de l'Indochine du 1er janvier 1919 au 1er juillet 1921. *In* Bul. Agr. Inst. Sci. Saigon, ann. 3, p. 307–323.
Maladies de l'Hévéa, p. 314–319. Abstract in Rev. Appl. Mycol., v. 1, p. 157–160, 1922.

VINCENT, E.
1919. Brown bast again. *In* Planters' Chron., v. 14, p. 819–821.
Comments on letters from correspondents.

1919–20. The brown bast mystery. *In* Planters' Chron., v. 14, p. 483–491, 761–763; 15, p. 291–293.
Résumé of articles in Malayan Tin and Rubber Journal, and a lecture by Petch, published in Times of Ceylon. Includes notes by "Keralam" on treatment suggested by Harmsen.

1920. Hevea seed. The Surinam leaf disease. *In* Planters' Chron., v. 15, p. 277–278.
Quotes recommendation of Ceylon Agricultural Experiments Committee, published in Trop. Agr., v. 54, p. 112–116, 1920, that Hevea seed from South America be excluded on account of prevalence of leaf disease.

VISCHER, W.
1921. Over samengestelde kurkhuidvorming en naruurlijke bast-vernieuwing bij Hevea brasiliensis. *In* Arch. Rubbercult. Nederlandsch-Indië, jaarg. 5, p. 486–494. (Meded. Rubberproefstat. "West-Java.")
English summary: Cork formation and bark renewal in *Hevea brasiliensis*, p. 493–494. Disagrees with Gandrup (Arch. Rubbercult., jaarg. 5, p. 389–398).
"It is evident that also diseased tissue may be carried toward the outside and thrown off."

1923. Enkele mededeelingen over drie ziekten van het tapvlak, indrogen, streepjeskanker en mouldyrot. *In* Arch. Rubbercult. Nederlandsch-Indië, jaarg. 7, p. 28–43, illus. (Meded. Rubberproefstat. "West-Java.")
English summary: Notes on three diseases of the tapping cut—drying out, stripe canker, and moldy rot, p. 42–43. Drying out is a physiological effect; stripe and patch canker are caused by Phytophthora; moldy rot is caused by *Sphaeronema fimbriatum.*

VRIENS, J. G. C.
1914. Heveaziekten. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1914, p. 9–12. Also in Indische Mercuur, jaarg. 37, p. 872. 1914.
Diseases caused by Gloeosporium, Fusarium, *Phytophthora faberi, Hymenochaete noxia,* and *Fomes semitostus* are discussed.

1914. Heveaziekten. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1914, p. 25–29.
Discusses die-back, canker, and brown root disease.

1915. Insterving. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915–16, p. 19–21.
The serious diseases of Hevea in Sumatra are said to be those due to *Fomes semitostus, Phytophthora faberi, Corticium salmonicolor, Hymenochaete noxia,* and *Thyridaria tarda.* The last is the cause of die-back, which is described.

VRIENS, J. G. C.—Continued.
1915. Phyllosticta hevea Zimm. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915/16, p. 22–23.
Found on leaves of Hevea in Sumatra.
1916. Kanker. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915–16, p. 31–36.
Describes various types of cankers caused by *Phytophthora faberi.*
1916. Afvallen van jong blad bij Hevea. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915/16, p. 59–60.
Leaf-fall caused by Fusicladium in Sumatra.
1916. Spinnewebziekte. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915/16, p. 66–67.
Thread-blight on twigs caused by *Stilbella heveae.*
1916. Verslag over 1915 en de eerste helft van 1916. Rubber. Ziekten en plagen. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur no. 6, p. 72–75.
1916. Ustulina zonata. *In* Alg. Vereen. Rubberplanters Oostkust Sumatra, Meded. Adviseur, 1915/16, p. 67–68.
Root disease found in Ceylon and the Federated Malay States.

W., E. D.
1909. À propos des parasites animaux et végétaux des caoutchoutiers. *In* Bul. Assoc. Plant. Caoutchouc, v. 1, p. 35–36.
Lists species of fungi occurring on Hevea, Ficus, Kickxia, and Manihot.

WAKEFIELD, E. M.
1917. Nigerian fungi, III. *In* Kew, Roy. Bot. Gard. Bul. 1917, p. 105–111.
Parts I and II do not report any fungi growing on rubber plants. *Ustulina zonata* is reported in Part III.
1921. Bark diseases of Hevea brasiliensis. *In* Agr. News [Barbados]., v. 20, p. 14.
On black-stripe and moldy rot. Quoted largely from Sharples and Belgrave, Black stripe and moldy rot, and Sanderson and Sutcliffe, *Sphaeronema* sp. (Moldy rot of the tapped surface.)

WARD, R.
1921. Report on the Botanic Gardens. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana, 1919, p. 56–65.
Leaf diseases prevalent at Christianburg, Demerara River, and Hills Estate, less virulent than in 1918.
1922. Report on the Botanic Gardens. *In* Rpt. Dept. Sci. and Agr. Brit. Guiana, 1920, p. 40–50.
Leaf disease prevalent at Hills Estate, Mazaruni, and Issorora Experiment Station, the latter closed on account of the ravages of the disease.

WELLES, C. G.
1922. A provisional list of the parasitic fungi of the Philippine Islands. *In* Philippine Agr. Rev., v. 15, p. 149–202. Host index, p. 176–198.

WESTER, P. J.
1917. Rubber culture in the Philippines. *In* Philippine Agr. Rev., v. 10, p. 201–220, illus.
Rubber pests, p. 219–220. Fungi listed are *Fomes lignosus* (*F. semitostus*), *Hymenochaete noxia, Corticium salmonicolor, Phytophthora faberi, Botryodiplodia theobromae, Ustulina zonata,* and *Poria hypobrunnea.*

WESTERDIJK, J.
1915. Phytopathology in the Tropics. *In* Ann. Mo. Bot. Gard., v. 2, p. 307–313.
General discussion of plant diseases. Hymenomycetes causing root diseases and die-back (*Corticium javanicum*) reported on Hevea.

W[ILDEMAN], E. D.
1912. Engrais dans la culture des caoutchoutiers. *In* Caoutchouc et Gutta-Percha, ann. 9, p. 6037–6041.
Use of lime tends to check root diseases such as *Fomes semitostus.*

WILSON, G. W.
1914. Studies in North American Peronosporales. V. A review of the genus Phytophthora. *In* Mycologia, v. 6, 54–83, illus. Bibliography, p. 80–82. *Phytophthora faberi,* p. 73–75.

WOLLENWEBER, H. W.
1917. Fusaria autographice delineata. Collectio specierum et ex herbaris variis selectarum et ab auctore lectarum cultarumque synonymis et excludendis additis quas determinavit, in sectiones digessit, comparavit cum Hypocreacis analogis praemissis ad methodi naturalis normas et culturae purae experientiam. *In* Ann. Mycol., jahrg. 15, p. 1–56.
Mentions *Fusarium theobromae* on Hevea.

WRIGHT, C. H.
1925. The modern aspects of disease control on rubber estates. *In* India-Rubber Jour., v. 70, no. 18, p. 15–16; no. 19, p. 17–19.
General diseases.

WRIGHT, H.
1906. Hevea brasiliensis or Para rubber, its botany, cultivation, chemistry, and diseases. Ed. 2, 179 p., illus. Colombo.
Diseases of Para rubber trees, p. 145–154.

1912. Lectures on rubber. No. 5. Diseases of rubber plants. *In* India-Rubber Jour., v. 43, p. 1064.
There are four important diseases: Canker and fruit diseases caused by Phytophthora, pink fungus, die-back (Botryodiplodia), and *Fomes semitostus*. Summary of lecture also in Planters' Chron., v. 7, p. 404, 1912.

WURTH, TH.
1917. Werkzaamheden in het belang van de rubbercultuur, verricht aan het Proefstation Malang. A. Ziekten en plagen. *In* Arch. Rubbercult. Nederland.-Indie, jaarg. 1, p. 188–196.
Taken from Jaarsverslag Proefst. Malang, 1916.

YATES, H. S.
1918. Fungi from British North Borneo. *In* Philippine Jour. Sci., Ser. C, Bot. v. 13, p. 233–240.
Lists eight fungi found on *Hevea brasiliensis*, including *Hypocrea borneensis*, n. sp.

1918. Some recently collected Phillippine fungi. Pt. II. *In* Philippine Jour. Sci., Ser. C, Bot., v. 13, p. 361–384.
Eutypelia heveae and *Tryblidiella mindanaoensis* on *Hevea brasiliensis; Rhizopus artocarpi* on *Artocarpus integrifolia*.

ZIMMERMANN, A.
1901. Die thierischen und pflanlichen Feinde der Kautschuk und Guttaperchapflanzen. Bul. Inst. Bot. Buitenzorg 10, 27 p.
Contents: A. Die parasiten der Moraceen (Ficus und Castilloa). B. Die parasiten der Euphorbiaceen (Hevea und Manihot). C. Die parasiten der Apocyneen (Willoughbya, Landolphia, Chonemorpha, und Alstonia). D. Die parasiten der Sapotaceen (Palaquium und Mimusops). Descriptions of eight new species.

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